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THE DESIGN OF THE PROPOSED WATER FILTRATION PLANT AT BALTIMORE[1]

BY JAMES W. ARMSTRONG[2]

Plans for Montebello Filters were started about the middle of 1912, and the plant was put in operation in September, 1915. About seven and one-half years of operation have followed: years that have revealed both the strength and the weakness of the plans as they were carried out and put into practice. One of the results growing out of a combined designing and operating experience is greater patience under criticism that has no constructive value, and a willingness to depart from previously accepted standards if a suggestion or an idea may be worked out for the good of the job.

In designing the new plant, the writer has endeavored to profit by past experiences and has departed in some particulars from the usual practice. Some departures have been made with the hope of improving the operation, and others for economy in construction. In some instances plans have been followed not at all to the liking of the designers, due principally to local conditions and topography; and, in some cases, features which seem to be desirable were abandoned because of the difficulty of working out practical details.

[1] Presented before the Detroit Convention, May 22, 1923.

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SOURCE OF SUPPLY

The City of Baltimore receives its water supply from the Gunpowder River, a small stream, having a watershed of 306 square miles above Loch Raven, where in 1912–1914 a concrete dam was built to form an impounding reservoir. The foundation for this dam was made adequate for future extension, but its crest was only built to elevation 188, a height little more than sufficient to act as a diverting dam.

Recently, in response to a long felt need for a greater reserve supply of water, this dam was built 52 feet higher, and at present has a 288 foot spillway, at elevation 240. The reservoir formed covers 2500 acres, holds 23 billion gallons and has a shore line of about 50 miles. A tunnel 7 miles long and 12 feet in diameter connects the dam with Montebello low lift pumping station, where it terminates in a shaft 16 feet in diameter, which acts as a suction well for the pumps.

Five centrifugal pumps having a combined capacity of about 250 million gallons per day are placed radially around this shaft, which occupies a central position in a round building, whose floor is 24 feet below the ground level. The pumps discharge into a 6 foot 6 inch circular conduit which is formed in the building wall, and an 8 foot concrete conduit forms the connecting link with the existing filters. Another 8 foot conduit will connect the pumping station with the new filters. This conduit is designed to take the pressure of water back of a 270-foot dam should the one at Loch Raven ever be raised to that elevation.

The dam is now sufficiently high to force water onto the filters by gravity, but tests revealed the fact that there was a weak place in the tunnel, not far from Loch Raven, at a point where it crosses the valley of the Mine Bank Run. In order to make the tunnel safe against leakage under pressure of water back of the new dam, it would have been necessary to reline a portion of it, but as it did not seem possible to do this and supply the city with water at the same time, another expedient, the building of a balancing reservoir, was adopted to prevent pressure coming on the tunnel.

An earth dam having a concrete spillway at elevation 200 was built across the small valley in which the weak place was discovered. A reservoir of about 10 million gallons was thus formed in the depression at the lowest point of which a 12 foot concrete shaft was

sunk intersecting the tunnel. Openings in this shaft, 10 feet below the surface, permit water to flow freely in or out. For instance, if water is admitted to the tunnel faster than it is required by the pumps at Montebello, it raises the level of the reservoir or overflows the spillway. If, in an effort to regulate the gates at Loch Raven Dam, sufficient water is not admitted to the tunnel to supply the pumps, the deficiency is admitted from the reservoir. The operation has been entirely satisfactory, and although the balancing reservoir has reduced the suction lift on the pumps 8 feet, pumping is still necessary.

CONTROL CHAMBER

As the different pumps have different capacities, it is not hard, under present conditions, to get a combination giving about the desired rate of discharge, but when the time comes for operation of the new plant it will not be quite so simple a matter to divert the right volume to each. Water flowing to the existing plant passes through a gate chamber planned for the regulation of aerators, which offers a possible, but rather unsatisfactory, means of control. It will, therefore, be best to regulate the future division of flow at the new plant.

An underground control chamber is to be built adjacent to the chemical building, formed by terminating the 8 foot raw water conduit in a semi-spherical end, placing outlet castings in the side, opposite similar castings in the 10 foot conduit passing through the plant. Thirty-six inch hydraulic valves will connect the castings. This arrangement will allow either manual or automatic control. In addition, should a new tunnel be built in the future, it could be terminated in a manner similar to the raw water conduit. Castings will be provided in the 10 foot conduit for the purpose of allowing connections with a future tunnel.

FEATURES TENDING TO CHEAPEN THE COST OF CONSTRUCTION

It has been the aim in designing the new filters, to cheapen the construction over that employed in the existing plant as much as possible, without in any way reducing the quality of the materials or workmanship. Among the things that have been done with this object in view are the following:

1. The placing of filters directly on the ground and omitting the filtered water basins under the filters.

2. The substitution of paved slopes for reservoir walls of the reinforced or gravity type, wherever conditions of construction permit.

3. The substitution of wooden baffles for concrete, except for the main baffle of the coagulating basins.

4. The omission of covers from the mixing basin and the filtered water reservoirs.

5. The omission of the entire collecting and strainer system as usually employed in mechanical filters and the substitution of a wooden slat bottom.

6. The omission of all collecting or distributing pipes under the filters.

7. The removal of influent conduits from the filter galleries, and the using of one or two filter walls for part of the conduit construction.

8. The placing of the wash water tanks in the transept over two filter units centrally located, instead of erecting a separate building for that purpose.

By omitting the basins under the filters, saving is made in excavation and in the heavy floors, roofs and columns necessary to support the filters. A filtered water basin of the same capacity costs much less if built separately. The deep excavation required and the firm character of the earth indicate that the paved slopes will be satisfactory and economical.

As Baltimore already has a number of uncovered clear water reservoirs in service, it is thought that omission of the cover over the basins at the new plant would not materially add to the trouble with algae growths. If such troubles are encountered in the future, and cannot be properly taken care of with copper sulphate, covers can be added. The plans have been prepared to permit this with a minimum of expense.

FEATURES TENDING TO INCREASE THE COST OF CONSTRUCTION

Owing to certain conditions affecting the location, and because of the unsettled state of the labor and material market, the following features tend to make the proposed work more expensive than that of the existing plant:

1. A large amount of excavation made necessary in order to secure a proper hydraulic gradient.

2. Long raw and filtered water conduits, and drains.

3. Large water conduits and equipment in order to permit of future extensions.

4. The addition of equipment for the manufacture of alum.

5. High prices of labor and materials.

6. The construction of a road through the grounds, separating portions of the plant.

7. The construction of the suction well and certain walls of a future pumping station.

When the existing filter plant was constructed, it was built on the only available ground owned at that time by the city, and it occupied practically all the space sufficiently high and available for the purpose. This made it impracticable to increase the present filters by extension. The city subsequently acquired a tract of about 40 acres of ground on the west side of Hillen Road, which in some ways provided an ideal site for filter location. In two particulars, however, it greatly added to the cost, for it necessitated an unusually large amount of excavation, approximately 300,000 cubic yards, and the separation of the grounds into two parts by the Hillen Road, which is 120 feet wide, and the placing of the buildings at an angle with the road, in order to take advantage of certain topographical features, and to secure better architectural effect, necessitated much longer conduits and drains, than would otherwise have been required.

Had work for the new filters been advertised six months sooner, a very substantial saving in the cost of construction might have been effected. On account of the rapid advance of prices and the unsettled condition of the market in the early sping it became necessary to make certain omissions from the plans in order to keep within appropriated funds. The administration building was omitted altogether. Slight modifications were made in the mixing basin, coagulating basin no. 1, and coagulating basin no. 3 was omitted altogether. Four filter units were also omitted. The omissions effected a saving on the first contract of about $200,000.00.

CONTRACTS

It is planned to divide the new work into more contracts than is usual in filter construction, but to divide them in such a way as to make each contract coincide with the particular interests of the party to whom the work is to be let. For instance, the first contract amounting to over one million dollars was awarded to the Carozza-Rowe Construction Company. It included all the grading, con-

crete, steel reinforcement and such minor articles as it was necessary to incorporate with the work, but items that are frequently embodied in a general contract and afterward sub-let, will be subjects of separate contracts and awarded directly to the manufacturer. Valves, sluice gates, pipe and specials, filter equipment, electrical equipment, heating plant, meters, elevators, tanks and various pieces of machinery are some of the items scheduled for separate award.

This division adds considerably to the work of the engineering staff and places upon the engineer much of the responsibility that is usually placed upon the general contractor, but it enables him to deal directly with the party doing the work and is generally much cheaper. Frequently, savings from 15 to 25 per cent may be made and more satisfactory results may be obtained.

FILTERS

There are to be 24 filter units of 4 million gallons each, arranged along two galleries. Plans contemplate the addition of 24 units at some future time, or an increase at normal ratings from 96 to 192 million gallons per day. The entire filter area is to be covered with a building, and the walks over the filters are wide enough to permit a Nichols sand washing machine to be moved along them. Water is to be conveyed to the filters in channels from the back, instead of from the pipe gallery as is usually done.

The filters will be built directly upon the ground without collecting or distributing piping under them. The controllers will be placed in a pit adjacent to the filter walls and the effluent after passing through them, will flow through concrete channels into a rectangular concrete conduit, which will occupy a central position in the pipe gallery. Water will flow through the conduit toward the chemical building, where chlorine will be applied at a point where the effluents from the two galleries mingle as they enter the outlet conduit.

This arrangement permits a flat floor in the pipe gallery, as the floor slab forms the top of the effluent conduit. The writer knows of no other plant where the pipe gallery is so free from piping or obstructions.

FILTER BOTTOMS

In 1901, Mr. Charles Hermany designed the first Louisville Filters, which along with the Little Falls Plant, were the pioneers

in large mechanical filter plant construction. Little Falls became the prototype of the modern filter, but the writer believes the Louisville Filters as originally designed by Mr. Hermany to be right in principle, and that, if the construction details of the Louisville Filters had been adequately worked out, and the gravel layer of sufficient depth to distribute properly the wash water, the history of mechanical filter design might have been very different.

A knowledge that the volume and rate of applying wash water could be varied greatly and still secure an even distribution over a large filter bed, led the writer long ago to question the value of a strainer system. As far back as 1917 or 1918 he conceived the idea of substituting for the strainers a system of slats for supporting the gravel and of providing a shallow compartment under the slats to permit of an unrestricted flow of wash water. Others had already planned filters with false bottoms, but all of them contemplated the use of strainers or some form of restricted opening.

The design of the new Montebello Plant is predicated upon the assumption that, within practical limits of applying wash water, strainer holes have no real value except to insure the delivery of water at the end of the distribution system, and, with the substitution of a small reservoir under a false bottom for the distribution system, the strainer or restricted opening ceases to be of any value whatever. It is planned to make the supporting bottom for the gravel and sand of 2 inch x 8 inch dressed pine planks spaced one inch apart. There is a shallow compartment beneath for the distribution of wash water. To accomplish this distribution, the velocity head of the entering water is practically all converted into pressure head by being discharged downward against the floor of the lower compartment. A well graded gravel layer, 18 inches thick, will then complete the distribution.

Before these plans were adopted, one of the existing filters was thrown out of service, and half of it, a space 13 feet 6 inches x 53 feet 6 inches was equipped with a slat bottom, which supported about 18 inches of gravel. Before placing the sand in this unit, it was subjected to a rate of wash of five vertical feet per minute, or two and one half times the ordinary rate, without ill effect. Air was then admitted to the wash water pipes, and the 24 inch valve was opened wide, thus subjecting the gravel layer to water hammer. Immediately over the air outlets the disturbance was very great and water was thrown at least a foot above the surrounding water

level. It was suspected that the gravel would be entirely displaced, but an examination revealed a disturbance too slight to be of any moment. After a few tests of this kind, no fear was felt as to the proper distribution of wash water or the displacement of gravel. The filter has now been in regular operation for about two years and has given good service.

WASH WATER GUTTERS

It is the regular practice at Montebello Filters to draw down the water on the filter beds to within a few inches of the sand surface before washing. It generally happens that the water drains out faster on one side of the center gutter than on the other. This difference in time of draining was taken as an indication that the sand was not equally graded in the two halves of the same filter.

In order to test this, a careful sieving of the sand in each of the 32 filters revealed the fact that we had 64 different kinds of filter sand. In no two filters was the sand in the two halves the same. It was evident that the two halves of any filters were not doing the same work, yet they were regulated by a common controller. In reality, the central wash water gutter made two independent filters that were regulated by a single controller.

Early in the stage of planning, it was decided to place the longitudinal or main gutter on one side instead of in the center, thus permitting the sand to become hydraulically graded and insuring a homogeneous filter bed. In the existing plant the lateral gutters are 1 foot 10 inches in width and are spaced 6 feet 8¼ inches, center to center, a distance a little too great to get the best rate of flow toward the gutter edges. The first plans contemplated an extra lateral gutter to reduce this space, but as they had to extend entirely across the filter, it became necessary to make them 2 feet 10 inches wide, and the extra width reduced the space between gutters over which the surface water has to travel by about one foot.

FILTER SAND

It has been the custom to specify filter sand in terms of effective size and uniformity coefficient. These terms were worked out in connection with slow sand filters, where sand was placed in its natural bed in the filters, and was never disturbed. In mechanical filters where the application of wash water lifts and hydraulically grades

the sand, these terms are meaningless. They are not only meaningless, but they are very misleading. It is the belief of those in charge of Montebello Filters, that filter sand should be, as near as possible, of a uniform size from top to bottom of the bed. What that size is we are not prepared to state at the present time.

We know, however, that in the summer time when organisms are numerous and the sand grains are heavily coated with organic matter, a very coarse sand may be satisfactorily used, but in winter a much finer sand seems desirable, as turbid water will then pass through a sand that will give perfect results in the summer time. As it is not possible, however, to change sand with the seasons, we are conducting experiments which we hope will reveal to us the size and depth of sand that will give the best results under all conditions of operation.

FILTER RATE CONTROLLERS

Filter rate controllers of the Venturi type are to be provided. They are required to operate accurately between rates of 2 and 6 millions gallons per day and are designed to limit the maximum rate of flow only. The elevation of water in the reservoir will be made use of to regulate flows less than the maximum, by reducing the head against which the filters operate. As the water level rises, it will gradually decrease the rate of flow, until it reaches the level of the water on the filters, when it will automatically cease. With the drop of the water level, the rate of filtration will gradually increase, until a maximum, for which the controller is set, is reached.

A gauge recording on a single chart both rate of flow and loss of head will be used. The pens will make concentric circles, so that the rate of flow and loss of head may be studied together with a minimum of inconvenience. Where a half chart or separate charts are used, it is quite difficult to compare loss of head and rate of flow gauges.

VALVES

During the seven and a half years that the Montebello Filters have been in operation, considerable trouble has been experienced in operating some of the hydraulic valves, especially the wash water valves, which are placed in a horizontal position with the discs parallel with the floor. The lower discs in these valves are provided with rollers, which for some reason or other, after a fairly

short period of service, have worn flat, and the leakage from these valves has gradually been getting worse and worse, until at the present time it has reached serious proportions.

As there are 16 valves in each filter gallery and it means the shut down of the entire gallery to repair a single valve, it is no easy matter to get repairs made. It is believed that a higher type of valve should be used for filter purposes, than has been customary in the past. In ordinary water works distribution systems valves are not operated frequently. Sometimes a year, and sometimes several years elapse between openings of valves, but in a filter plant the hydraulic valves are probably opened 300 or more times in a single year. It can thus be seen that a valve which might prove satisfactory in a distribution system, might not prove at all so in a filter plant. It is planned for the new plant to specify valves of the double disc type, but the lower disc, or the one which slides over the valve seat, is to be provided with heavy bronze mounted slides, which are to operate on bronze tracks built in the body and bonnet of the valve. Just before coming to a stop, the tracks will terminate in a wedge, which will permit the disc to drop into closing position before the wedging mechanism operates.

WASH WATER

The two concrete wash water tanks are built over two of the filter units, and are housed in the transept of the filter buildings. They are rectangular in shape and hold 134,000 gallons each and occupy a central position for the distribution of wash water. The pumps will be located under the tanks over a portion of one of the filter units and will take suction directly from the 10 foot water conduit beneath. There will be two 12-inch horizontal centrifugal pumps that discharge directly upward into the tanks. The wash water from the tanks will flow through a 30-inch pipe and Venturi meter to a 24-inch loop system in each gallery. From this 24 inch loop the water for washing each of the filters will be discharged vertically downward into the basin under the slats, which support the gravel and sand. The velocity of the inflowing water, as it impinges on the bottom, will be checked and the velocity head will be practically all converted into pressure head, which is desirable for securing a uniform distribution of wash water.

By having the pumps discharge into the tanks through separate lines, they may be run at the same time the water is being drawn

from the tanks and still not interfere with the correct measurement of the outgoing water. In addition to the regular Venturi recording apparatus, a 30-inch double faced illuminated dial will be placed on a column about the center of each filter gallery, so that the operator may see from any point in the gallery, the rate at which wash water is being applied. With the exception of the wash water pipes, the only ones in the lower gallery will be the small pressure mains and the heating pipes. The drain valve opens into a concrete passage leading directly into the main drain and the influent valve is placed on the back of the filters, against the wall of the coagulated water conduit.

CHEMICAL BUILDING

The chemical building occupies a position as nearly central to the plant as it was possible to locate it. It will serve as a manufacturing plant for alum and a place for mixing and controlling the application of alum solution, milk of lime and liquid chlorine. The tower will contain large storage bins for bauxite, lime and cake alum, and storage tanks for sulphuric acid. It will also contain the heating plant and all the machinery equipment.

Except for unloading from the cars, there will be little manual labor in connection with the handling of chemicals. The bauxite and lime will be lifted to the top of the tower and spouted into storage bins, from which they will be withdrawn and handled by gravity and by spiral conveyors through every subsequent operation, until they are applied to the water.

ALUM MANUFACTURING PLANT

It is planned to manufacture Hoover alum for purification purposes, which should prove economical for the following reasons:

1. Raw materials may be purchased by the city as cheaply as by any private concern.

2. There will be a saving in freight rates due to (*a*) the hauling of a smaller volume of material, as raw materials do not contain water of crystallization; and (*b*) a saving due to shorter hauling. All manufacturing plants, at least those from whom we have previously purchased material, have to haul raw material past our doors and ship the finished product back again.

3. No overhead expense. No additional office or executive force will be required.

4. Practically no additional labor will be required. With the installation of machinery for economic handling of raw material it will take little more labor for making the alum and applying it to the water, than it now takes for dissolving the cake alum and applying it to the water.

5. No manufacturers' profits are paid.

6. A greater reserve supply may be stored with the same bin capacity.

As against this apparent economy in making alum, there is the added cost due to the installation of the necessary equipment and the maintenance charges of the machinery. A good part of the machinery equipment, however, would be made necessary even if the old system of handling and dissolving alum should be used.

BAUXITE HANDLING

The bauxite will be received in bulk in carload lots and hauled by truck from the nearest railroad siding, which is about two miles from the plant. Here it will be weighed and dumped into receiving hoppers, from which it will be withdrawn directly into the pulverizer. After being pulverized to such a fineness that it will pass a sieve of 100 mesh to the inch, it will be lifted by means of a large fan to the top of the tower, where it will be passed through a cyclone collector into the concrete storage bins.

Bauxite from the storage bins will be withdrawn into spiral conveyors attached directly to the bin bottoms, and discharged into the weighing hoppers, which will be suspended in position over the boiling tanks. From the weighing hoppers, bauxite can be withdrawn at any desired rate at the will of the operator. The conveyors transporting the bauxite are about 85 feet long. As the motors driving them are about that distance from the operator, all motors are to be started by push buttons from the tanks, so that the operator can stop the flow of bauxite at the instant the scale dial shows that the required amount has been delivered to the hopper. As it will be impracticable to empty the conveyors after each weighing, the motors will have to be of sufficient power to start the conveyors when full of bauxite. Each motor will be provided with an overload relay to prevent the burning of the motor in case of trouble. As the conveyors will only run at about 50 r.p.m. and the 25 cycle motors operating them have a speed of about 720 r.p.m., it is planned to make the necessary reduction in speed by means of a single bevelled gear and silent chain drive.

ACID HANDLING

Sulphuric acid for the manufacture of alum may be purchased locally from any one of several companies. It is planned to haul all acid in a tank truck direct from the manufacturing plant where it can be loaded by gravity into the truck. It can also be discharged by gravity into the storage tanks at the filter plant. Both the truck tank and the storage tanks are to be made of steel, as 60 or 66 degree acid, which we intend to purchase, does not readily attack the metal.

Each of the storage tanks are 10 feet in diameter and 30 feet long, and hold 147 tons. They are provided with the necessary piping for venting and controlling the flow of acid to the acid wells. Compressed air will be used for lifting the acid to the measuring tanks, which are to be situated just above the boiling tanks. For manufacturing the liquid alum, strong acid will be applied directly to the tanks, but for making cake alum a lead lined acid dilution tank will be required.

MAKING OF ALUM SOLUTIONS

For the manufacture and control of alum solutions, six steel tanks, 15 feet in diameter and 17½ feet deep with semi-spherical bottoms are to be provided. Three of these tanks are to be used for alum boiling tanks and are to be lined with 10 pound lead. Each tank will have a single opening in the bottom, which will serve as an outlet for solution and as a drain. The acid, bauxite and water will all be admitted from the top. In order to prevent fumes and steam from escaping in the room, each of the three boiling tanks will be covered with a conical iron hood, which will terminate in a 30-inch vent pipe. Spray nozzles will be inserted in each of the vent pipes for the purpose of precipitating vapors and dust. Openings for inspection will be left in each hood and beside each opening a strong electric light shining through a glass plate in the side of the hood will enable the operator to observe the state of the chemical reactions.

CAKE ALUM

In the compartment to be used for the manufacture of cake alum, mixing pans are to be placed directly under the conveyors and the crystallizing vat will be on the floor beneath. The only opening will be the discharge from the mixing pan. It is planned to use a

Stedman mixer having a capacity of about 2000 pounds per batch. It is also planned to have the crystallizing floor equipped with a device for permitting the cake alum to be easily broken. When sufficiently hardened, it will be passed through the rotary crusher, and elevated through a bucket conveyor, spouted to the storage bins, from which it can be withdrawn into the truck for transportation to the existing plant.

CHEMICAL CONTROL

Alum solution will be diluted in the boiling tanks and in the auxiliary tanks directly to the required strength for applying to the water. The solution will be admitted from these tanks to the controllers, which will be situated directly under them. The piping leading the solution from these large tanks to the controllers will be of lead lined cast iron and will be the shortest length possible. All connections will be flanged so as to permit easy cleaning and flushing. The controllers will be made of reinforced concrete, 6 feet square inside and will hold about 3 feet depth of liquid, which will be kept at a constant level by means of a balanced valve operated by a very large float. It is planned to actuate the controllers by means of Venturi meters and they will be devised for either manual or automatic control.

The controllers will discharge directly into large concrete troughs placed directly under the floor, which will admit the solution directly to the water within a few feet of the point of entrance. The plans have been so designed that the alum may be added to the water coming in, to the water after passing through the first coagulating basin and immediately before going to the filters. This flexibility will permit corrective treatment, if it becomes desirable at any time, and three controllers are being provided in order to make this possible.

LIME

Lime will be received in bulk in box cars and will be hauled by automobile truck about two miles to the plant, where it will be weighed and lifted into overhead bins by means of a bucket elevator. It will be withdrawn from the bins into a spiral conveyor operated by an electric motor and discharged into the weighing hoppers, which will fit directly into rotary slakers. The lime will afterwards be admitted to concrete tanks, diluted to the required strength,

and passed through controllers similar to those used for alum. Piping will be of cast iron. The lime will be agitated by means of slow stirring paddles, actuated by belt-driven machinery from above.

In the existing plant, the agitators are driven by propellor blades revolving at about 720 r.p.m., the shaft passing up through stuffing boxes in the bottom of the tanks. While devices of this kind give very excellent agitation, we have found a great deal of trouble due to the leaking of the stuffing boxes, and on account of these troubles, the old fashioned stirring device has been adopted.

LIQUID CHLORINE

Liquid chlorine is received in cylinders in carload lots and will be stored in the lower floor of the chemical building. The compartment reserved for this purpose will hold about two carloads and will be provided with a ventilating fan, so that in case of leakage of the gas, the fan may be started from outside the room and the gas exhausted. The chlorine room will be on the second floor of the building, and will be divided by a partition into two separate compartments, one containing the scales upon which the cylinders are weighed, and the other the chlorinator and scale dials. The scales will be built especially for this purpose and will be set flush with the floor. An overhead trolley will be installed for handling the cylinders. The scale dials will have double faces and a glass plate in the partition will permit them to be read from either room. By using separate rooms, the operator in adjusting the chlorinator and taking readings for weights of chemicals will not be compelled to go into the tank room. This room will also be provided with an exhaust fan to be used in case of trouble with gas.

DUST PROOF

To handle a dusty material and at the same time to keep clean, is one of the things we are trying to achieve. Past experience will at least enable us to avoid some of our former mistakes.

In the existing plant the receiving scale is covered by an open porch, which in windy weather permits a considerable volume of dust to be blown against the building every time a load is dumped into the crusher pit. This in time becomes a matter of serious concern, if appearance is to be taken into consideration.

The receiving scale for the new plant is to be covered with a building having a single entrance. No windows whatever are to be provided. The receiving hoppers are well inside of the tower, so that when chemicals are dumped no dust should be blown outside of the buildings and tight inner partitions prevent dust from reaching the interior. The bauxite after being pulverized will be conveyed through air tight tubes and a cyclone collector into the storage bins. Dust tight spiral conveyors will be attached directly to the bin bottoms, and the space between the conveyors and weighing hoppers will be connected by cloth to prevent the escape of dust at those points.

Cake alum and lime will be passed through a rotary crusher into a conveyor, which will discharge into overhead storage bins by means of a bucket elevator enclosed in a dust proof steel case. In the compartment where the crusher is to be located, and where dust is inevitable, there will be no openings in the partitions except for a door.

VENTURI METERS

When the existing filters were designed, a Venturi meter was placed on the raw water line and used for the application of coagulant, but no provision was made for a meter on the filter effluent lime. As the liquid chlorine and lime are both applied to the filtered water, trouble was occasionally experienced in regulating the proper amount to be applied, on account of the fact that the output from the filters frequently differed considerably from the amount being pumped into the plant. It was thought that occasional tastes which occurred in the water were due to the inability to control closely the chlorine application. In order to secure better chemical regulation, a 10 foot concrete Venturi meter with a brass lined iron throat piece is to be placed on the raw water line and in the filter effluent line. The two meter registers will be situated side by side, so that they may both be seen at the same time.

MIXING BASIN

There has been considerable controversy regarding the best type of mixing basin, and the fact that there seems to be no general consensus of opinion on the subject may be partly accounted for by the difficulty of securing experiments where all factors, except

the one under consideration, are eliminated. It may also be that different waters do not respond equally well to a given treatment. The Montebello mixing basin is to be provided with baffles of the round-the-end type for the following reasons:

1. An excellent floc has always been secured in the existing plant with baffles of this type.

2. The hydraulic grade line of the old and new plants must be the same, consequently no type requiring different operating conditions could be used.

3. A carrying velocity is maintained under average operation conditions. A velocity too slow to carry sediment will permit a deposit which will fill the channel until a carrying velocity is reached and any great increase in velocity will pick up sediment until the required area of the channel has been secured.

4. A minimum possible pumping lift is secured at all times, as a low rate of flow means a low head to pump against, and an increased rate of flow only increases the pumping head sufficient to overcome the friction losses.

In the existing plant water is pumped into the mixing basin against a fluctuating head that decreases and increases with the pumping rate. The necessity for operating the new filters under the same hydraulic conditions has prevented any serious consideration of the over and under, or any other type of mixing device that requires operating under fixed pumping conditions.

The round-the-end type of baffle occupies middle ground between the extreme types, being worked out by Professor Hyde and his assistants at Sacramento, and the hydraulic jump planned by Mr. Ellms, for Cleveland.

The Sacramento plan employs very gentle mechanical stirring without violent agitation and maintains a continuous rotary motion through the mixing basin, the time element thus becoming a very important factor. The Cleveland plan employs violent agitation for a short period, the time element being almost neglected.

Careful experiments made at Montebello in actual plant operation, under various rates of flow and conditions of water, have proven beyond question, that there is a decided advantage in every turn of the water up to a certain point. After that, the value apparently decreases. An account of the experiment is described by Edward S. Hopkins in the *Engineering News-Record*, vol. 90, p. 204. The value of each turn might be divided into two com-

ponent parts, one of which is agitation and the other is time. It has been impossible to tell just what value should be given to each. Laboratory experiments, where a uniform stirring is given, seemed to indicate that, while the main value is in the stirring, there is also considerable value in the time element.

The baffles are to be built of dressed lumber and the portions above the minimum flow line will be painted with a black bitumastic paint. The columns are spaced 7 feet on centers and are made of three pieces; 2 inch x 4 inch and two pieces of 2 inch x 8 inch nailed together, so as to form grooves for receiving the 1 inch planks, which form the baffles. The bottom of the columns are secured in position and the lateral thrust is resisted by a simple casting placed in the concrete floor. The tops are braced by timbers running across the basin both ways, and the cross bracing is made strong enough to take the top reaction of the accumulated thrust of the water against the baffles, which amounts to about 4800 pounds at the top of each column at the last turn. The time of detention in the basin, at the normal rate of operation, will be about 35 minutes.

COAGULATING BASINS

There will be two coagulating basins, each about 105 by 380 feet, with an average depth of 13 feet 6 inches and a combined capacity of 13½ millions gallons. A single concrete baffle extends backward about three-fourths of the length of the basin on a line slightly inclined to the sides. The purpose of the inclination is to make a gradually increasing cross section of water-way from the inlet to the outlet. This should effect a corresponding decrease in velocity and allow a little greater time for subsidence as the water approaches the outlet.

A gutter with a slope of 1½ feet per hundred is located on each side of the baffle. In the existing plant the only outlets from the 12-inch flushing line are at the ends of similar gutters. The water from these outlets is a great help in carrying sludge to the drain, but, except for a limited area near the end of the basin, it has little other value. In the new plant a 12-inch flushing line extends entirely around each basin, and valves are provided every 50 feet. The frequent spacing of valves should prove very helpful in removing sludge, as it requires more water than the fire hoses, which are used in cleaning, can supply to properly float the sludge. Raw water is used for flushing.

Submerged wooden cross baffles are contemplated for the purpose of better distributing the surface flow across the basin and for forming a lower quiet zone to permit of the uninterrupted settlement of the suspended matter after it has once begun to settle. (cf. THIS JOURNAL, June, 1919, and July, 1920.) The baffles are designed as cantilever walls and have sufficient strength to withstand the pressure of 6 feet of liquid mud, when the opposite side is empty. Instead of outer walls the slopes are to be excavated to the required outline and paved with concrete.

FILTERED WATER RESERVOIRS

It is planned to build two filtered water reservoirs at different levels. Advantage is taken of the topography to build the smaller reservoir on higher ground, so that its top will be the same level as the top of the filters. The lower reservoir is built so that its maximum water level will be elevation 213, the same as the water surface in the existing plant. The lower reservoir will hold about 19 million gallons and the upper reservoir will hold about 8 million gallons. On account of the fact that the lower basin is connected with the present reservoir, it will be impossible to raise the water above that in the existing plant. The smaller reservoir is built for the purpose of regulating the rate of flow from the filters, of maintaining a maximum head in the suction well of the future pumping station and of flattening the peak load of the filters. The operation will be somewhat as follows:

When the water level in the lower basin drops below elevation 213, some of the valves connecting the upper and lower basins will automatically open and allow water to enter the lower basin. This will continue as long as the water continues to recede in the lower basin. As the water rises in the lower basin, it will automatically cut out valves connecting the two basins, until the maximum water level is reached. The water will then begin to rise in the upper basin and will continue to rise until it reaches the point, where, on account of the reduced head, it will begin to choke down the rate of filtration. Should there be no further withdrawal of water, it will continue to rise until it reaches the same level as the water on the filters, in which case filters would cease to operate, owing to the fact that there will be no available head for forcing the water through them.

As the pumps are to take suction from the upper basin, it may be seen that they would always operate under a minimum possible suction lift. It will also be apparent that, during the night when the rate of filtration is generally light, water could be stored up in the upper basin against the demand during the hours of the day when water consumption is the greatest.

As there is a large quantity of earth to be disposed of, it was decided to make the embankment of the lower reservoir of earth. The rolled section will be made with a slope of 3 to 1 on each side and with a crest 20 feet wide 5 feet above the maximum water level. The downstream slope will be flattened with unrolled earth. The earth from which the embankment is to be made is mostly of a good quality of clay, which when rolled will be almost as good as a clay puddle. The inner surface is to be paved with concrete to a height 1½ feet above the high water line. The reservoir is to be left open, but provision is made, in case algae growths become too troublesome, so that a cover may be added later at a minimum cost. Foundations are made adequate for carrying the concrete roof and the 2 feet of earth covering.

PUMPING STATION

The logical place for the construction of a pumping station for supplying the northern part of the city is Montebello, as it will thus be nearer the territory to be supplied and can take suction from the basins without the necessity of water having to traverse the mains. A portion of the pumping station will be built in connection with the smaller filtered water reservoir, and sluice gates for the control of the water are to be constructed at the present time, inasmuch as it will be difficult to build them in the future.

ARCHITECTURE AND GROUNDS

Montebello Filters are situated in a tract of about 250 acres of ground owned by the Water Department. The ground is rolling and unusually attractive in appearance. There is sufficient space between the existing and the new plant to allow a distinctive treatment of each group of buildings.

The new buildings will be of red brick laid with wide raked out joints and covered with green tile roofs to harmonize with the present buildings, although the architectural features will differ in

many particulars. The type of architecture will be Northern Italian, the details of which have been pleasingly worked out by Mr. Wm. W. Emmart, the consulting architect.

PERSONNEL

Mr. Wm. A. Megraw, Water Engineer and President of the Water Board, has general supervision of all construction work undertaken by the Water Department. Mr. Willard B. Jones has general charge of the drawing room and will have general supervision of the construction of Additions to Montebello Filters.

IODINE TREATMENT OF WATER FOR PREVENTION OF GOITRE[1]

By Beekman C. Little[2]

The statements to be made concerning the particular malady discussed in this paper have been gleaned from the writings and opinions of others than myself, for I know little about the cause or treatment of goitre.

The Water Bureau and the Health Bureau of Rochester, working together, believe thay have evolved a plan for successfully treating and preventing goitre. With great emphasis on the latter: for *prevention* is the ideal we seek.

Having great faith in the idea, I desire to launch it here at this Convention and to have the American Water Works Association broadcast it to the world. It is earnestly hoped, therefore, that you will bring the matter before the health officers and medical associations of your respective communities.

Simple goitre is a disease which has probably come to the attention many times of every one here. It is generally recognized as a swelling of the neck due to the enlargement of the thyroid gland. The extent to which goitre prevails is seldom appreciated. In the entire world there are few countries free from goitre districts and sporadic cases of goitre exist in every section and nationality in the world.

In North America, goitre is endemic, especially and continually prevalent in the whole of the Great Lakes region and in the basin of the St. Lawrence and in the north-west Pacific region.

The seriousness of the disease itself may be learned with little investigation. There is a relation between goitre and cretinism or idiocy, marked by physical deformity and degeneracy.

Statistics are not always reliable, but it is safe to say that in this region along the Great Lakes, in Detroit or in Rochester, 7 out of every 100 school children are afflicted with goitre. In addition, a large proportion of all the women who consult physicians have the disease.

[1] Presented before the Detroit Convention, May 23, 1923.

[2] Superintendent, Water Works, Rochester, N. Y.

Certainly this is a disturbing condition and any promising suggestion for its alleviation should receive at least attention.

Iodine is a natural constituent of the normal thyroid gland. It is essential to normal thyroid activity. The amount of iodine required is exceedingly small, but, when this amount is absent, the thyroid gland seeks by increase in size and surface to make up for this lack in iodine, and goitre is the result. In fact, goitre has been described as an adaptation to "iodine-deficient" nutrition. It follows, therefore, that the treatment for goitre, now pretty generally practiced, is the giving of very small dosages of iodine. The small amount of iodine now considered necessary is indicated by the fact that 1/10000 of a gram of iodine taken daily over a period of 15 or 20 days is an accredited prescription. This dose is given twice a year, once in the spring and again in the fall.

A recent study from the laboratory of the University of Minnesota, by Dr. J. F. McClendon, shows clearly the inverse ratio between the amount of iodine in surface water and the distribution of goitre. In the neighborhood of the sea, the air and water contain much more iodine than in inland places, and these places distant from the sea have high goitre incidence.

What we propose to do is to introduce into our drinking water a very minute quantity of iodine and thus bring to the human system and the thyroid gland that which it needs, and otherwise lacks, to function properly.

This idea of dosing every one willy-nilly is startling but not unknown, so that it is not altogether revolutionary. For instance, in Switzerland, where goitre is prevalent, it was decided last February, in one canton, to incorporate a small amount of iodine in all the table salt used. All civilized persons take daily a certain quantity of salt and, as it is inexpensive and the Swiss Government can control this article of food, it seemed to be the proper carrier for the iodine.

This way of doing it, even if it were possible in this country, does not seem to have the advantages of the water supply method.

In the recommendation of our plan in Rochester, Dr. Goler, the Health Officer, states:

1. We always have in Rochester, among our children, more than 2000 cases of preventable goitre.

2. We have so much simple goitre because of the absence of minute quantities of iodine in our food and drink.

3. We may prevent this goitre by the addition of minute quantities of iodine to the drinking water in the amount of $\frac{2}{10{,}000}$ of a gram to a gallon, in the form of iodide of soda.

4. Iodine seems to be required by the body. When taken into the body in these minute quantities, it is fixed by the thyroid gland and its enlargement, and consequent goitre, is prevented.

5. If we put iodine in the water, it will be necessary to dose the water only twice a year, for two weeks. This would require each day 13.3 pounds of iodide of soda for two weeks, or 372 pounds at $4,80 per pound, or $1785.00 a year.

6. To prevent goitre would cost less than $2000.00 a year. The addition of this minute quantity of iodine would also affect favorably young persons already having goitres. It would not affect that form of goitre known as "Graves Disease" or exophthalmic goitre. It would not affect older goitres.

The Water Bureau at Rochester has already started this treatment of the water. At one of our reservoirs, from which is drawn all of the water entering the city mains, we have dissolved daily—for a period of two weeks—16 pounds of iodide of soda, a slightly greater amount than first suggested.

Our consumption of water during this period was approximtely 25 million gallons per day. In the laboratory of the Health Bureau, and checked up by chemists in the University of Rochester laboratory, accurate check was kept and it was found that the iodine content in the water increased from 1 part in a billion parts of water, before the experiment, to 20 parts in a billion after the addition.

Next fall the dose will probably be increased, as it is planned to get about 50 parts of iodine to one billion parts of water.

It is calculated that such a water, prevailing for two or three weeks, twice a year, will give to those drinking of it freely approximately the amount of iodine needed to bring to a close the story of simple goitre in Rochester.

PUMP SELECTION[1]

By B. R. Vanleer[2]

GENERAL CONSIDERATIONS

In selecting a pump for a given installation one must be guided by the same general principles which govern the selection of any mechanical apparatus. First and foremost the integrity of the pump manufacturer must be assured. The financial status of the manufacturer must be investigated. The length of time the pump has been on the market, its performance for other purchasers must be known and weighed carefully before a decision is made. It does not pay to purchase a pump from a concern whose business is run on a shoe string basis regardless of how well the mechanical features of the particular pump may appear at the time. The reason for this is that very few water works may employ a staff of highly trained engineering specialists. In fact, I believe in the entire state of California there are only three cities which have special engineers to look after their water works equipment. Hence the managers of the various water works of this state are compelled to a large extent to rely upon the engineering knowledge and experience of the manufacturer from whom they purchase their equipment. This is an excellent procedure, provided, of course, the pump manufacturer has an established character, because the engineering staffs employed by most of the large pump manufacturers surpass in training and experience any staff which the average water works could employ. Furthermore, the men who compose these various staffs are thoroughly honest and are guided by the code of all true engineers. The trouble is that too many pumps are purchased upon the elusive statements of salesmen who give vague and indefinite promises which the engineering staff of the company could not and would not guarantee. When purchasing a pump, as in the purchase of all mechanical apparatus, the terms of the agreement should be reduced to writing.

[1] Presented before the California Section meeting, October 26, 1922.

[2] Assistant Professor, Mechanical Engineering, University of California, Berkeley, California.

FIRST COST

The initial expenditure for a pumping unit is frequently a difficult problem, and it is generally the first thing considered by the prospective purchaser. In considering *first cost* there are two things which should always be borne in mind; first, it rarely if ever pays to buy *cheap* pumps, secondly, engineering skill can make almost anything for which there is money to pay. In other words you can get a pump which will satisfy your requirements and you will be the loser in the long run if you accept a makeshift substitute simply because it is cheap. The scientific way to consider *first cost* is to determine the requirements of your pumping unit and then pay what you must in order to secure a pump which will fulfill those requirements. If bids are submitted which equally satisfy the requirements, from pump manufacturers who are equally reliable and dependable, then the lowest priced unit would naturally be chosen.

DEPENDABILITY

Water works are essentially public utilities. They may not be owned by the public, but the public is dependent upon them. Water works must deliver water at all times and many factors of safety are introduced to assure the accomplishment of this purpose. It is because of these facts that the dependability of a pump plays a very important part in its selection for water works use. There are water works pumps which must run continuously twenty-four hours per day for months at a time. Breakdowns are costly and destroy the morale of the pumping plant force, and the confidence of the people who use the water. This must not be tolerated in a water works pump.

That pump is most dependable which causes the fewest shutdowns during its life. This quality may not be determined by reading the catalogue of the pump manufacturer or by listening to the suave conversation of the salesman. It may be ascertained in only two ways, by actual experience and by a careful inspection of the maintenance records of another water works which has used that particular pump. Therefore, if the purchaser does not know, from actual personal experience, it is well to ascertain from at least three previous customers the dependability of the pump under consideration before it is purchased.

DURABILITY

That quality which gives a pump lasting value as a water lifting device, that which causes it to have the longest life of usefulness, is called its durability. This quality is of importance because upon it is based the sum to be set aside each year for depreciation and replacement.

Durability is dependent upon the material of which the pump is constructed, its general design proportions, the type of pump, the kind of service to which it is subjected, and the care given it during its life. Obviously these variables are of such character that the life of a pump cannot be computed with any degree of certainty. However, there is one thing which gives a fair figure for computing the depreciation upon a pump and that is its obsolescence. So rapid have been the advances made in the engineering sciences during the past half century that recognition or distinction must be made between the life of a pump and its efficient life. In other words, a pump may be pumping at the end of twenty years at practically the same efficiency with which it functioned at the end of its first year of use, and with perhaps a few repairs it may continue to function for another twenty years, but long before that time a more efficient and cheaper way will have been discovered to accomplish the same work and it would pay to purchase a new pumping unit.

The rule then on durability is to inspect the pump to be purchased carefully to see that it is well designed, that sufficient metal is allowed so that the bearings are large and arranged to be copiously lubricated, that the pump is well cared for and then allow it a life of ten years, in computing depreciation and replacement.

WATER

Since this paper is limited to water pumps, the problem is complicated by the kind of water in use, for water as usually pumped is never pure and sometimes its constituents make pumping a more serious problem than it ordinarily would be.

The water may be highly corrosive and may contain chemicals which soon destroy pumps of the centrifugal and piston types. In such cases pumping by air is the only recourse and usually solves the problem nicely.

There are two other enemies of the pump operator, sand and air. Sand is found in most water pumped from wells and it must be

kept out of certain types of pumps, otherwise their efficiency and useful life is materially reduced. Centrifugal pumps are frequently used where the amount of sand is not excessive, but in this type of pump the runners may soon be worn out. Due to their simplicity, however, the runners or impellers may be easily and cheaply replaced. Here again air-lift pumping has a decided advantage over other methods of pumping, unless the sand may in some way be separated from the water before it is to pass on through the pump.

Water which contains a great deal of air or gas is likewise difficult to pump. If a centrifugal pump is used it is continually loosing its prime. If the piston or direct displacement pump is used the capacity and efficiency of the pump is materially decreased, to say nothing of the serious trouble caused by water hammer and variations in the pressure. Deep-well turbine pumps act very well under such conditions and it is sometimes advisable to lift the water by stages in order to overcome the difficulty which excess air in the water may cause. The pumping of sewage is a most difficult problem and the author is of the opinion that some kind of trouble will be encountered in the pumping of sewage no matter what kind of pump is used.

The conclusion then to be drawn from this discussion on the kind of pump to use when pumping water containing a destructive chemical, fine sand or air is this: Use an air lift unless the cost is prohibitive. In other words, an air lift will probably cause less trouble and cost less over a period of ten or twenty years than will other types which are continually wearing out.

TOTAL HEAD

The total height through which water may be forced is limited only by the power available and the strength of the pump and pipe connections. The total head of the air lift system is quite limited on account of its cost of operation and the fact that, to secure the best efficiency, it should have a submergence of about 50 per cent. Hence it is not used to any extent where the lifts exceed 250 feet. The centrifugal pump has been used where the total head exceeds 2000 feet. It is not to be recommended, however, for heads over 750 feet on account of the first cost of the pump and the fact that as the stages increase the efficiency of the pump is materially lowered. Where the head is high, the pump which is generally most efficient.

mechanically and commercially, is the piston or plunger pump. In fact it will generally be found to be the most efficient for heads of over 300 feet.

SUCTION

Most of the difficulties with pumps are caused by the suction. The term suction must not be confused with the depth below the surface of the ground from which a pump can raise water.

The following definitions will be used in this paper:

Suction is the reading of a vacuum gage in feet of water when connected to the suction side of the pump.

Lift is the vertical distance from the pump proper to the free surface of the water.

Depth of pumping is the distance from the ground surface to the free surface of the water to be pumped.

The suction is dependent upon the atmospheric pressure, which is governed largely by the altitude and the temperature.

The table below shows the variation of suction with the altitude.

ALTITUDE ABOVE THE SEA-LEVEL	THEORETICAL SUCTION POSSIBLE IN FEET OF WATER
feet	
0	33.9
2000	31.4
4000	29.1
6000	27.1
8000	25.2
10000	23.2

The lift must always be less than the suction because the latter includes pipe friction, friction due to strainers, foot valves, elbows, velocity head, as well as lift. When pumping water the lift is also materially affected by temperature, as the following table shows:

	TEMPERATURE OF WATER AT SEA-LEVEL				
	60°F.	100°F.	140°F.	180°F.	212°F.
Maximum theoretical lift, feet	33.0	31.4	27.7	16.7	.0

Because of these limiting factors the lift generally should not exceed 15 feet and never 20 feet. The rule regarding lift should

be to eliminate it if possible by having the water flow to the pump under a positive pressure. If this is not practicable, then the suction pipe should be made as large as possible and all friction reduced to a minimum. The greater the lift, the greater the amount of trouble and the less efficient the pump will be.

In passing, it may be noted that, when it is necessary to throttle centrifugal pumps, it is more economical to throttle them on the suction side. Notwithstanding the fact that their efficiency is decreased, the total amount of power consumed is less than when they are throttled on the discharge side.

Depth of Pumping

The factors which affect the depth of pumping are: the cost of excavation, the size of the pumping unit, the theoretical suction possible, and the manner in which the power is transmitted to the pumping unit. Time does not permit a detailed discussion of how each of these factors limits the depth of the pumping. This much must be made clear, however, that most of the pumping for small water works is now done from wells whose depth is such that the cost of excavation prohibits the use of centrifugal or triplex plunger pumps, and, when rod pumps are used, the quantity is small, when the air lift is used the cost of operation is high and when the deep well turbine pump is used, the cost of installation and upkeep is great. Therefore, it must be emphasized that all of the facts herein presented must be taken merely as generalizations. Each pump selection is an individual problem and must be treated as such.

SIZE, WEIGHT AND FLOOR SPACE

If the size, weight and floor space, which a pumping unit is to occupy, enters into its selection, as is frequently the case, the deep well turbine pump, the centrifugal, rotary, and jet pumps have a decided advantage, because they are small in size and weight and occupy little space. On the other hand, reciprocating pumps and the air lift with its auxiliaries occupy a large amount of floor space and are large and heavy.

EFFICIENCY

In considering pumps there may be said to be three kinds of efficiency. The mechanical pump efficiency is the ratio of the

output of the pump itself to the input to the pump. This is a simple straightforward engineering relationship and any good engineer with the proper means at his disposal may measure quite accurately the mechanical efficiency of a pump, which for various types of pumps now in use varies from 25 to 95 per cent.

The overall or plant efficiency is the ratio of the power output of the pump to the power input to the plant. This efficiency takes into consideration the losses in transmission of power from the prime mover to the delivered water. In case the power purchased is electric, the efficiency is figured from wire to water and, in case the power is generated in a steam plant, the efficiency is computed from fuel to water. This is generally the determining factor in the selection of a pumping plant, because this efficiency may usually be obtained quite readily and it may be reduced to dollars and cents. In other words, a prospective purchaser can be told just how much it will cost him to pump a gallon of water.

The third efficiency is called the commercial efficiency. This is the efficiency which *should* govern the selection of the pumping plant. It is the total cost per unit volume of water pumped during the entire life of the pump. The commercial efficiency takes into consideration the first cost, the cost of installation, insurance, taxes, depreciation, operation, upkeep, repairs, replacements and all losses between the power received and the water delivered. This is a very difficult quantity to measure or to obtain because it will never be exactly the same for any two pumping installations. If care is exercised in considering all of the factors, the commercial efficiency may be approximated in advance and under no circumstances should this be neglected. Always compare the *commercial efficiencies* of the pumping installations under consideration.

FLEXIBILITY

The flexibility of a pump is the ease with which it can be made to meet changing conditions of operation. For example, if the suction under which a pump is operating becomes greater, how will the pump respond, or if the head or quantity changes can the pump be made to meet these conditions?

The flexibility of centrifugal pumps, air lifts, piston or plunger pumps is limited. In fact all pumps are more or less inflexible and, if good efficiency is to be maintained, pumps *must* be operated

under the conditions for which they were designed. The reciprocating steam pump and the rotary pump seem to have the greatest flexibility.

PRIMING AND STARTING

With the exception of the air lift, the rod pump and the deep well turbine pump, it is necessary to prime the more common types of pumps in use in California. Priming is the process of filling the pump from the water surface to the discharge side of the pump with water instead of air. This is accomplished in many ways, such as by the use of a foot valve and auxiliary source of water, by means of a steam injector, or by means of a hand or a vacuum pump. If the pump has to be frequently shut down this item must be given careful consideration, and with centrifugal pumps it is one of the most serious objections. When a foot valve is used the losses through it are very high and it is continually becoming clogged and refusing to work right at the time when it is needed most. Foot valves should be avoided whenever it is possible. In selecting a pump be guided by the following:

1. Avoid the necessity of priming, if possible.
2. Make the process of priming as simple as possible.
3. When frequent stops are necessary and time is an element in starting make sure that there are at least two ways of priming the pump at hand.
4. When purchasing a pump which requires priming, take into consideration the extra cost of the auxiliary priming apparatus.

CAPACITY

Capacity refers to the quantity in gallons per minute which a pump will deliver. Here again it must be remembered that almost any capacity may be had in almost any type of pump if the money is available. Generally, however, centrifugal and deep well turbine pumps and their like are quantity pumps, that is, they are used where the head is low or moderate and where the quantity desired is large. Piston and rotary pumps and their like are used where the quantity desired is small or moderate and the total head great. Rod pumps and air lifts, used only in special cases, are employed where the quantity is moderate and the lift great or the well small.

SPEED

In the selection of pumps the speed, which refers primarily to the speed of the prime-mover is of importance, because the greater the speed the less will be the first cost of the prime-mover. On the other hand the less the speed the less will be the wear on the apparatus. Generally speaking, reciprocating pumps must operate at a slow speed and rotary pumps, centrifugal and deep well turbine pumps operate at speeds above 1000 r.p.m. The modern tendency is toward rotative apparatus which operates at higher and higher speeds. By the use of silent chain drives, belts, gears, etc., high speed prime-movers may be used for reciprocating pumps. There is of course a slight loss due to transmission, but this is more than offset by the increased efficiency of the reciprocating pump. If reciprocating pumps are not operated at their proper speed they may knock and the quantity which they are supposed to deliver may be materially changed. If centrifugal pumps are not operated at their proper speed everything will be different, because the quantity varies directly as the speed, the head as the square of the speed and the power required as the cube of the speed. Therefore in selecting a pump one must be certain the pump may be operated at the speed for which it is designed and that the speed required of the prime-mover by the pump is a standard speed for that class of prime-movers.

PRIME-MOVERS

Probably every type of prime-mover which has been used by man has been required to drive pumps. Hence it is obviously impossible to discuss all of them in this brief paper. Mention will be made of only those which are used extensively in California.

Because of their economy and the fact that steam is already available for other purposes, the direct acting steam pump is still extensively used, but because it occupies less floor space and affords some gain in economy the direct connected steam turbine is gaining in popularity.

California's vast network of electric power has made possible the extensive use of the electric motor drive, which has the following advantages:

1. Reliability.
2. Low first cost.

3. Low maintenance expense.
4. Small floor space requirements.
5. Great freedom from noise and vibration.
6. Small foundations.
7. Cleanliness.
8. Ease of control (manual or automatic, near or remote).
9. Low operating expense (skilled attendant not required).

SUMMARY OF ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF PUMPS

In conclusion, the advantages and disadvantages of the various types of pumps are briefly set forth below to act as a general guide in selecting a pump for a given installation.

A. The reciprocating steam pump has the following advantages:
   1. Low first cost.
   2. Great durability.
   3. Good flexibility.
   4. Will operate against a high head.
   5. Operation well understood and a high efficiency usually obtained.

   It has the following disadvantages:
   1. It requires frequent adjustment.
   2. It can not pump sandy water.
   3. It is heavy and occupies a large floor space.
   4. It is complicated.
   5. Priming is usually necessary.

B. The piston or plunger pump has the following advantages:
   1. Great durability.
   2. Operates against a high head.
   3. Has a uniform flow for multi-cylinders.
   4. The efficiency is high.
   5. The suction is good.

   The piston pump has the following disadvantages:
   1. High first cost.
   2. Its flexibility is limited.
   3. Its weight is great and the floor space occupied is large.
   4. It must operate at a slow speed.
   5. Priming is necessary.
   6. It will not pump sandy water successfully.

C. The rotary pump has the following advantages:

1. It is small and occupies little floor space.
2. It is fairly flexible.
3. Easy to operate.
4. Starts quickly.
5. It is unnecessary to prime.
6. Has a uniform flow.

Its disadvantages are:

1. High first cost.
2. Very poor durability.
3. Limited speed.
4. Limited head.

D. The air lift has the following advantages:

1. Pumps any kind of water.
2. Priming is not necessary.
3. Several wells of varying depth can be pumped at the same time.
4. There are no moving parts below the surface of the water.
5. The air lift itself occupies little space.

It has the following disadvantages:

1. The first cost of unit, including auxiliary air compressor, is moderately high.
2. The discharge head is limited.
3. The operating or mechanical pump efficiency is very low.
4. The flow is intermittent.

E. Centrifugal pumps have the following advantages:

1. Low first cost.
2. Excellent durability.
3. Small weight and floor space.
4. Easy and simple to operate.
5. They start quickly.
6. The flow is steady.
7. The speed of operation is high.

Their disadvantages are:

1. Necessity of multistaging to produce high pressures.
2. Their lack of flexibility.
3. The low suction possible.
4. The necessity for priming.

F. The deep well turbine pump, which the author believes will be the well pump of the future, has the following advantages.

1. Moderate first cost.
2. Small size, weight and floor space.
3. Easy and simple to operate.
4. It starts rapidly.
5. Operates at a moderate speed.
6. Has a constant and large flow of water.
7. It is not necessary to prime.

It has at *present* the following disadvantages:

1. Very low durability.
2. It is not very flexible.
3. It operates against a limited pressure.
4. Only a moderate mechanical pump efficiency.

The author hopes that the generalizations herein set forth will lead the prospective pump purchasers of California to a more careful study of the problem of pump selection, so that more water may be pumped for less money.

THE ADVANTAGES AND DISADVANTAGES OF ELEVATED CONCRETE TANKS FOR WATER STORAGE IN MINNESOTA[1]

By Arthur S. Milinowski[2]

The language of the subject assigned to me for discussion demands comparisons of a kind which depend on whether emphasis is on the word "elevated" or "concrete." Laying stress on the "elevated," and by "elevated" I mean a tank artificially raised on some sort of a supporting sub-structure, one finds oneself immediately comparing a tank, be it concrete or not, that is wholly at a considerable elevation above the ground, with a reservoir built at the ground level or below it. As between these two forms one thing only, an important one, may be said in favor of the elevated tank, that it provides a structure capable of being located conveniently near the center of distribution, for the storage of water plus potential energy. In other words, water on which all of the work necessary to deliver it to the main has already been performed in leisure time and which is, immediately available therefore, for domestic and fire purposes and independent of the risks of pumping equipment failure during an emergency. Such a tank is immediately robbed of this one great advantage in any specific case, when a natural and conveniently placed hill allows the building of a reservoir at or below ground level, but sufficiently high above the distribution system to give an adequate pressure. The obvious disadvantage of an elevated structure is that its cost, for any given capacity, is far above that of a reservoir built at or below the ground.

Non-elevated storage tanks have many important uses even when they do not furnish the necessary pressure to supply the distribution system by gravity. Some of these may be enumerated as follows:

1. An underground or surface reservoir serving both as a means of collecting and of storing water.

[1] Presented before the Minnesota Section meeting, October 27, 1922.

[2] Of Druar and Milinowski, Consulting Engineers, St. Paul, Minn.

2. A clear water basin holding the effluent from filters, iron removal plants and the like.

3. Pressure tanks, depending on a constantly maintained and renewed pressure for their effectiveness.

In all of these, with the possible exception of the last-named, further mechanical work must necessarily be performed to deliver the water to the point of consumption. Installations of air pressure tanks are comparatively rare. They depend for their effectiveness on the constantly and mechanically maintained air pressure and they are not free, therefore, from danger of failure at critical times.

It is clear that the only, but important, use of the elevated tank is to provide water storage in districts having no natural and conveniently located hill, under a potential head and in a manner requiring no further force than gravity to deliver the water where and when needed. The importance of having constantly available a public water supply under pressure, independent of a sudden breakdown of mechanical equipment, is obvious for any community. The value of elevated tanks to provide for the storage of water under these desirable conditions is particularly evidenced in Minnesota with her large area of comparatively level land and a vast number of such installations have been made in this state.

I might say a word here respecting standpipes, that is, reservoirs whose height is several times the diameter and which are designed to contain water throughout their height. Such structures are being built in decreasing number because this shape is not an economical one. That is, an equal volume of water may be stored in a tank of greater diameter and less height, requiring the use of a smaller amount of structural material. In addition, when the water is low in such standpipes, they usually furnish a pressure below that most advantageous for the normal operation of the system which they supply. The lower portions of such pipes, therefore, though designed for heavy water pressure, really act only as supports for the body of water representing the effectively stored quantity. It has been found more advantageous to do away with this dead storage and the elevated tank, in which the center of gravity of the stored water remains more nearly constant, has been developed.

In what I have said so far, I have adhered to the strict use of the term "elevated tank." In what follows, I ask to be allowed to make only two distinctions, namely, artificial reservoirs, or tanks above the ground, whether elevated on a tower or built directly on the

ground and those built practically wholly in the ground. I also take the liberty of laying little stress on that portion of the assigned topic which refers to Minnesota, although when I refer to the effect of frost and ice, I have a climate such as ours in mind. But, in general, the considerations I wish to discuss apply, except for the severity of local climate, to tanks everywhere. It is interesting that, when one comes to analyze it mathematically, the effect of temperature stresses in a concrete tank is of less importance than might be imagined. The real effect of cold weather is of an entirely different nature and I will have occasion to refer to it later.

If we place the emphasis on the "concrete" phase of tanks great possibilities for lengthy discussion as to the relative merits of concrete, steel and wood for use in elevated tanks become apparent. Let us first examine the extent to which these materials have been used for water tanks or reservoirs underground, that is, in direct contact with earth. We find that wooden tanks rot in a short space of time, not those portions that are kept constantly wet, but the parts above the natural ground water that are alternately wet and dry as the water in the reservoir rises and falls. Their covers especially are subject to quick decay. The result is that wood has been commonly replaced by concrete for reservoirs of this description. The interior of steel tanks in such locations may be protected temporarily to a certain extent with paint and this may be renewed, from time to time, but the exterior, in permanent contact with the ground, but still not entirely protected from the rust producing combination of air and moisture, cannot be so protected. In such locations concrete again has become the popular and common substitute. Underground concrete storage tanks are now the rule. They have been found satisfactory, are permanent and require no maintenance.

Now let us examine the situation regarding storage tanks above ground. The two popular forms are, of course, of wood and steel. Only a comparatively small number of concrete tanks built above the ground are in existence. Wooden tanks are widely used for railroad purposes. Their usefulness here is due to the ease of erection by the maintenance or construction crews regularly employed and the facility with which they may be removed to new locations as the demands of traffic change; to the fact that railroads usually have, at their disposal, at low cost, the timber of which to construct them and that they have developed standard plans from which they may be cheaply built. It is due in some measure probably also to

the fact that the gases from locomotives do not damage them. It has also been stated that they provide that flexibility which is of advantage to a structure subject to the vibrations set up by passing trains, because steel structures may tend to crystallize thereunder. The consideration which prompts the selection of wood tanks for public and private water supplies is probably always the lower first cost, for it may be accepted as a generality that their useful life, which will not average over twenty years, as compared with that of steel structures, make the latter by far the better investment from an economic standpoint. But, in many instances, the capital is simply not available that would allow the larger but more advantageous investment. Wooden tanks are being replaced today in ever increasing numbers by steel tanks whose life, when properly cared for mainly by periodical painting, may be much longer. I say "may be" advisedly, for it is a fact that much waste of money is occasioned by neglect, especially in municipally owned tanks. Railroads and private corporations, on the other hand, usually are careful to maintain their steel tanks properly and hence get the fullest use out of them. Undoubtedly, too, progress in the science of protective pigments for steel—and there is much room for such progress —will greatly extend the average life of steel structures of all kinds. This progress, together with the increasing scarcity of lumber, will cause a continued substitution of steel for wood tanks.

In addition to the cost of proper maintenance, both wood and steel tanks have another shortcoming where used above ground. Neither lends itself to pleasing architectural treatment. They are built for utility only, in a mechanical age, in which it is highly desirable that art and beauty of form should wherever possible be combined with mere mechanical efficiency and effectiveness.

Just as we have seen, in the case of underground tanks, a gradual replacement, in the interest of prolonged life, lower maintenance cost and, consequently, greater total saving, of wood and steel with concrete, so we have noticed for tanks above ground a gradual replacing of wood with the more permanent steel. But here the analogy ends. The most important forward step so far taken for the purpose of improving upon the steel tank is not, as above, the substitution of concrete, but rather an earnest search for better protective means, as paints. The great desideratum in a material for water tanks above ground is one that is reasonable in first cost, will not require repairs or any particular maintenance expense and

may be given any desired architectual treatment. Concrete is such a material. Then why has not concrete, found so satisfactory for underground reservoirs, taken the place of steel for reservoirs above the ground?

I mentioned the title of this paper to a friend the other day and he said "Why don't you tell them the truth? Tell them that the advantages are that, concrete, costing more than steel, gives a bigger fee to the designing engineer. The disadvantages are that they leak like hell." Of course, it is true that the constant trend toward improvement has been at work in the case of water tanks above ground as much as on those built below it. Great success in the use of concrete for the former cannot be recorded. Seven years ago, only about forty such tanks or standpipes were generally known to have been built in the United States. Today, the annual rate of increase in the number of concrete tanks built has not materially increased and the reason actually has been that many have leaked. I do not wish to enumerate the concrete tanks that have been constructed or to state in each instance the details of the leaks that developed, the attempts that have been made to repair them and the success and failure of these attempts. Some of these concrete structures have been fairly successful, but many cannot be called so by any stretch of the imagination. There have hardly been any absolute failures, cases where the structure collapsed. The principal difficulty has been seepage either through porous places in the concrete, through small or large cracks, probably due to shrinkage of the concrete while setting, or to expansion of the structure when the water load was applied. In addition, there have been leaks through the joints between different days' work and through cracks due to rupture of the green concrete when slip forms were used. One particular seat of trouble has been at or near the junction of the circular shell to the floor, due usually to the stresses set up when the more or less flexible shell was bonded to the rigid floor. These leaks are mostly minor from the point of view of loss of water, but they are detrimental because the water, in penetrating the concrete, freezes on the outside in winter in this climate and causes the breaking off of portions of the concrete shell, exposing the reinforcing steel and, unless repaired, allowing the latter to rust out. Indeed it is likely that even without the actual breaking of the concrete, sufficient air may reach the metal reinforcement in leaky tanks so as gradually to destroy it. There is also an entirely different reason why it will be

necessary to solve the problem of keeping even small leaks from appearing, before concrete as a material for water storage tanks above ground will ever come into general use, namely, the effect on the owners and the public. Engineers would know that, barring the effect of rust, a properly reinforced concrete tank is not in danger of collapsing even though it leak torrents. To see a structure made to hold water covered with little rivulets in summer and decorated in winter with icicles like a Christmas tree does not exactly tend to please the layman, however, if, indeed, it does not have the effect of actually causing a grave doubt as to the stability of the whole structure. Were it not, therefore, for the fact that, with the present methods of designing concrete tanks, an absolutely water tight tank has practically never been achieved, there is no doubt that concrete, for this purpose, would come into as much use as it has for underground reservoirs. Concrete reservoirs placed underground are obviously built under the most favorable conditions. They are usually not heavily reinforced and hence are comparatively free from internal shrinkage stresses tending to rupture the concrete. They are backed up by solid earth which, in the case of circular tanks, gives a pressure tending to keep the concrete walls in compression. They are protected from drying out and from great variation in temperature, while leakage from underground reservoirs, unless of unusual proportions, is never a cause of worry because its effects may neither displease the eye nor, since such a reservoir is protected from the cold, may such leakage become harmful to the structure. Such tanks, too, when the necessity arises, are not difficult to waterproof.

Obviously if we are ever to take advantage of the good qualities of concrete as a material of which to construct water tanks above the ground, a different method of design and construction must be found than has heretofore commonly been used.

It has been particularly interesting to me during the last two years to investigate a design proposed by Mr. Wm. S. Hewett, Member A. S. C. E., of Minneapolis, which so impressed me with its probable merits that we are now building, at Barnum, Minn., a reservoir 20 feet in diameter and 32 feet high in accordance with the principles laid down by him. Briefly stated, it consists of a concrete shell 7 inches thick, unreinforced except in a vertical direction, built of as dense concrete as practicable. This is allowed to cure to a certain extent, care being taken to keep the concrete moist during this time in order to reduce as much as possible any

shrinkage of the concrete. Thereafter, plain round steel hoops are shrunk onto the exterior of the shell and tensioned by means of turnbuckles to a uniform initial stress of some 15,000 pounds per square inch. This will place the concrete in compression. Water is then admitted to the tank in order to test it. Then an outer three inch ring of concrete or gunite is applied over a wire mesh securely fastened to the steel hoops for the purpose of protecting the steel and furnishing it with additional bearing. The amount of the initial stress and the behaviour of the concrete and steel, when the hydraulic pressure is brought upon them, is observed by strain gauge measurements. The idea is to have a structure in which the concrete, even under load, will be in compression or at least not in tension. This design, it is confidently expected (and this expectation is borne out by tests on 30 inch pipe with 2 inch walls) will produce a tank the concrete of which will never be in tension and which, therefore, if properly proportioned, mixed and placed will not leak. In practice, porous spots in the concrete itself may appear and there is the possibility of places where poor contact between successive rings or lifts will manifest itself by leakage, but it is expected that the condition of no tensile-stress in the concrete will favor the easy water-proofing of such places.

I have purposely avoided at this time going into the details of the various technical computations and practical considerations entering into the design and construction. The computations take account of the shrinkage during setting, temperature stresses, the now recognized effect of absorbed water in causing the swelling of concrete, even after it has entirely hardened, and, of course, the hydraulic load. The practical execution of the work demands the reading of strain gauges applied to the reinforcing hoops from which we expect to learn much.

We think we have provided for various practical difficulties which might be forseen, such as, for example, the tendency to have the greatest intensity of stress at the turnbuckles and the least stress midway between the turnbuckles owing to the friction of the rods against the walls of the tank.

Unfortunately this work has not yet been completed, but, when it is, we intend to publish the results, the details of Mr. Hewett's computations, the things we may learn as to the actual behaviour of the steel and concrete, and the details of the methods of construction.

UNDERGROUND WATERS[1]

By Charles H. Lee[2]

The use of water from subterranean sources for municipal and industrial purposes has been common throughout the United States for many years and in more recent years has extended to irrigation in the West. In California, approximately 50 per cent of the 253 municipalities depend solely upon underground water and 15 per cent are partially supplied from such sources. There were also in California in 1920, according to the last United States census, 26,800 irrigation wells with a total capacity of 10,900,000 gallons per minute.

The extensive use of underground waters in recent years has led to the systematic study of the occurrence and movement of underground water with particular reference to its development for economic purposes. The severe drought of 1898 to 1905 in Southern California, where land values were relatively high and depended upon a permanent supply of water for irrigation, first stimulated such study. Practicing hydraulic engineers in California have actively led in this work and through their efforts the United States Geological Survey has detailed permanently members of its staff to the study of underground water problems throughout the United States. This work has been ably carried on to the extent that funds were available and has resulted in the publication of much valuable information. During the war, valuable assistance was rendered military authorities, both by members of the Geological Survey staff and private engineers who entered the service. Today, as a result of such efforts, there has been accumulated sufficient information to begin the formulation of general ideas and principles which are of considerable value to engineers and those responsible for the development and operation of water works systems.

The writer has been keenly interested in the development of this subject for the past fifteen years and his experience in underground

[1] Presented before the California Section meeting, October 27, 1922.

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water studies and development, which covers the southwestern portion of the United States and much of France, has included a wide range of geologic formations and physical and climatic conditions. In the limited scope of this paper an attempt will be made to illustrate and outline in general terms, some of the principles and show their practical application to the underground water problems encountered in ordinary practice.

The scientific study of underground water is known technically as ground water hydrology and has made necessary the defining of ideas and the adoption of standard terminology. I shall not attempt in this short paper, however, to go into technical details other than to state that ground water is considered to be water that exists in a saturated formation, having a texture such that the water will move through it perceptibly under ordinary hydrostatic pressure. It is thus distinguished from capillary or suspended subsurface water, since the latter does not act under the influence of gravity. Capillary water is of interest only to the agriculturist as the supply which crop roots draw upon from the soil. Ground water, however, is the water that is available for development for the economic and domestic needs of man.

CHOICE OF LOCATION

The first question that arises when a decision has been made to investigate the possibilities of ground water supply for any purpose, is, where can water be obtained. If obvious sources are not apparent, such as springs, the answer is sometimes sought by employing a "water witch" who finds an "underground stream" or a "water stratum" with a forked willow stick. Sometimes this method is successful, often it is not. An alternative is to investigate the geological formations of the region with the purpose of selecting and carefully studying those which give promise of being sufficiently porous or fissured to contain water and so located as to have a regular source of replenishment from direct precipitation, stream flow, lakes, or artificial sources such as return from irrigation. Having found a water bearing formation, or aquifer, as it is now termed, if further investigation indicates that water of suitable quality may be obtained in sufficient quantity for the purpose desired, its development is feasible from the standpoint of relative elevations and cost, legal control of the land can be obtained and

the probability of interference with other users of water from the same supply are remote, the problem is reduced to one of practical development. These various requirements will first be taken up before going on to methods of development of ground water.

Water bearing formations

Although there are many local variations, it is possible to classify water bearing formations as to their character and occurrence. One of the most important classes is the *modern alluvium* which fills structural depressions of the earth's surface, or borders deeply eroded mountain ranges adjacent to continental coasts. The fill of structural valleys in California is an example familiar to everyone. The Atlantic Coastal Plain of the United States is another well known example. These formations usually consist of more or less extensive and regularly interbedded layers of unconsolidated gravel, sand and clay, of various thicknesses and are still in process of accummulation as the result of weathering of adjacent rock masses and stream transportation. Water is usually yielded in commercial quantity at a moderate depth, the average being much less than 500 feet and the maximum seldom exceeding 1000 feet. These formations are the most recent geologically and overlie the older sedimentary rock. Their upper surface is exposed to direct contact with precipitation and all bodies of surface water. This fact, together with the unconsolidated and porous character of the formation, gives it a leading place as a reliable source of underground water.

Glacial drift forms another important source of underground water. It resembles the modern alluvial deposits in material and occurrence, but its structure is irregular, water bearing sands and gravels, usually occurring in lenses or pockets, rather than broad sheets. Glacial drift occurs either in the form of till, a heterogenous mass of of clay, sand and boulders, or stratified drift which has been deposited by streams issuing from the ice. The latter is usually more productive as a source of water. The glacial drift provinces of the United States include the northern tier of states from the Atlantic Coast to the Rocky Mountains and the Puget Sound region. Glacial deposits in California are local, being confined to terminal and lateral moraines in mountain canyons.

There is an *older type of alluvium* which was deposited either just preceding or contemporaneous with the glacial drift, which is

often associated with modern alluvial deposits. This is composed of gravel, sand and clay, the two latter usually forming a matrix for the former and effectually filling the voids. Occasionally lenses occur in which the proportion of clay is small and the material has water bearing capacity. Such deposits, however, have a minor value for water supply. They occur around the margins of many valleys and along the coast of Southern California where they are distinguished by their reddish appearance. The theory has been advanced that they result from the decomposition of granite in contact with salt water. Extensive areas of ancient partially consolidated alluvium also occur in western Europe.

Directly underlying the alluvial and glacial deposits, or directly exposed to the atmosphere, are a great series of *sedimentary rocks* which occur throughout the world. These are solidified formations having distinct stratification and occur in continuous sheets of great thickness and area, often tilted or warped. Conglomerate, sand stone, marl, shale, chalk and limestone are all familiar examples of sedimentary rocks. Each has its characteristics subject to wide local variation. Marl and shale are impervious to water and are of importance in connection with ground water only as they affect its accumulation and circulation in adjacent porous formations. Sandstone is sometimes porous and yields large quantities of water, often under artesian head, as the famous Dakota sandstone of South Dakota and the green sand of England and "sables verts" of France. The famous artesian wells at Paris penetrate the latter. The older sandstones however, are dense, as are also chalk and limestones, and have no water bearing capacity except as they are broken up or fissured, or have joint or contact planes. Limestone is soluble under certain conditions and often is characterized by having extensive galleries or solution channels. Successful wells in such formations are entirely a matter of chance, although wells penetrating a fissured zone or solution channel often yield large quantities of water. The writer noted several wells in northeastern France, penetrating dense sandstone at a depth of 2000 and 3000 feet, which yielded large streams of water, while adjacent wells in similar formation were dry. An exception to the above statement should be made for the chalk formations of northwestern France and England. The chalk, although nonporous, is in these regions so generally broken up into fragments that wells penetrating this formation are almost universally successful. In California, the

stratified rock formations have little value as sources of commercial water supply.

The *crystalline rocks*, which underly the sedimentary rocks, are very dense and solid and do not yield water except as they are rendered porous by decomposition and removal of certain crystalline elements, or are fractured or jointed. Included in this class of rocks are metamorphic rocks, such as gneiss and schist, and igneous rocks, such as granite, diabase, etc. In the elevated portions of San Diego County, California, and the Brittany peninsula in France, granite is the prevailing rock formation and being exposed to the atmosphere, has decomposed to a depth of 30 to 50 feet. Where the rainfall is sufficient or irrigation is practised ,this formation constitutes an important source of local supply, although the quantity yielded is small as compared with more porous formations. The yield from wells in fissured or jointed crystalline rock is usually very small and drill holes often encounter no water at all.

Volcanic formations, such as lava flows or beds of volcanic ash and debris, are often quite porous and, under conditions favorable for natural replenishment, represent important sources of supply. Wells of local importance have been obtained in such formations bordering the Napa and Sonoma Valleys in California and also in the lava bed regions of eastern Washington, Oregon and Idaho. Large yields have also been obtained from wells in lava formations in the Hawaiian Islands. It is possible that many of the successful deep wells in the Sacramento Valley of California penetrate lava beds continuous with those appearing on the slopes of the Sierra to the east.

The first step in any search for a source of ground water is to locate a porous formation such as described above which has possibilities as an aquifer. The extent, position and character of the formation and adjacent formations should next be investigated. Finally, the intake and catchment areas of the aquifer should be determined, its catchment area including its intake area and all areas which contribute surface waters thereto. An aquifer may be entirely open to inspection and its limits easily determined, as in the case of the gravels of a river valley. There are many aquifers, however, which are hidden from view or in which there are hidden conditions, such as impervious walls resulting from faulting, which exert an important influence upon underground water circulation. The study of such hidden conditions often requires the special

training of the hydrologic engineer or geologist for their solution. Having found an aquifer and determined its limits, the probable yield should next be investigated.

Yield

The source of supply of an aquifer is absorption from surface water upon its catchment and intake areas. Such water may occur in the form of rainfall, melting snow, natural streams and lakes, artificial bodies of water such as reservoirs, irrigation canals and field irrigation. The yield of an aquifer is that portion of its supply which may be recovered for human use.

The adequacy of yield from an aquifer is not only a question of rate of pumping or flow from wells, springs or galleries for short periods of time, but of the permanence of the supply through a complete meterologic cycle of years. The possibilities of artificial influences must also be considered, such as the decrease in the available yield through the action of other wells, and the increase of the supply by facilitating the absorption of the surface water.

The rate of yield of springs or completed development is measurable at the time of an investigation. Either information as to past performance may be obtained or hydraulic studies of probable future behavior may be made.

The yield of wells, tunnels or galleries yet to be constructed, however, offer a problem for the trained judgment of the hydrologic engineer, guided by what information is available for similar developments either in the same local formation or a similar formation in other localities. Consideration must be given to differences of rainfall, exposure to absorption, rapidity of transmission through the formation, etc., in making such comparisons and whether existing developments have been made to the best advantage as to secure the greatest possible yield.

Considering aquifers in order of rate of yield, galleried or broken lava formations or soluble rock formations, such as limestone or gypsum in which solution channels occur, are the greatest producers. The great lava springs which are the source of Fall River, California, are examples of the first. The combined discharge of this group is seldom less than 1400 cubic feet per second. In France, the famous Fontaine de Vaucluse, issuing from limestone, is reported to have a normal flow equivalent to 770 cubic feet per second and a

maximum recorded flow of 4500 cubic feet per second. These extreme cases illustrate the possibilities of lava and limestone formations. Solution channels may also be the source for important well supplies, as in the gypsum formation in Pecos Valley near Roswell, New Mexico, where individual wells flow under artesian pressure as much as 9 cubic feet per second. Clean, open sand and gravel, porous sandstone and broken chalk are probably the next largest in point of yield. Tubular wells of ordinary capacity in such formations produce from 1 to 3 cubic feet per second and exceptionally good wells, 3 to 6 cubic feet per second. Smaller rates of yield are obtained from wells in fine sand or in graded alluvial material. Still smaller yields characterize wells in decomposed granite and crystalline rocks. The yields of wells in fissured or fractured sandstones and limestones vary widely and drill holes are often dry. As an example, the average yield of 18 pumping wells, drilled in more or less fractured limestone by the French military water service in the San Mihiel Sector, was 13 gallons per minute and the yield of the best well 62 gallons per minute. The average drawdown was from 60 to 90 feet. Twenty per cent of the holes drilled were dry.

The permanence of the yield of an aquifer depends upon the relation of the rate of recharge to the natural leakage plus artificial draft. The sum of the two latter quantities must not exceed the rate of recharge for any length of time if the yield is to remain permanent. Many aquifers are capable of quantitative study involving measurement of the rate of natural recharge and leakage. Although the detailed methods of conducting such studies are beyond the scope of this paper, it may be stated that in American practice there are at least four recognized methods of determining the yield of an aquifer. These have been termed the intake, discharge, water table and underflow methods. The first two methods involve measurements of absorption and loss respectively. The water table method is based upon water table fluctuations and porosity. The underflow method consists of measuring the rate of flow of ground water through a selected cross-section. Each method is adapted to meet special conditions of climate, topography, geology, etc., and all have been practically applied with success, notably in California. (See Water Supply Papers 294 and 446, United States Geological Survey.)

Hydrologic engineers in France and Germany have developed special methods which are applicable to typical aquifers in Europe. These methods, while generally not applicable to conditions in the United States, are useful wherever the physical conditions are similar to those for which they were developed.

The artificial replenishment of aquifers has probably been attempted on the largest scale in Southern California where surplus flood waters are spread over the extensive gravel cones of many of the larger streams with marked beneficial result. The capping of flowing artesian wells during periods of non-use has also proved very effective in this region. Special methods suited to local conditions may often be devised which will help to revive an aquifer suffering from overdraft. The latter condition is evidenced by continuing lowering of the water plane or decrease of artesian pressure.

Quality of water

There are three important phases of the quality of ground water to which attention should be given, namely, turbidity, mineralization and bacterial pollution. Turbidity is usually intermittent in its appearance, following heavy percipitation or surface run-off. It occurs mostly in springs or shallow wells directly connected with surface streams or receiving direct surface run-off through fissured rock. It not only renders the water temporarily unsatisfactory for use, but may be the source of dangerous pollution even when the water is clear. If springs or existing wells are to be used, careful inquiry should be made as to the appearance of the water during periods of storm.

Mineralization of underground water is usually a permanent condition which may be detected by chemical analysis of the water. If excessive and not likely to decrease by continued draft upon the supply, the use of such water is usually inadvisable. The determination of whether the amounts of dissolved substances are excessive is not a simple problem, as it depends not alone upon the total solids in solution, but upon the total and relative amounts of the individual chemical constitutents present. In general, it may be said that, for domestic purposes, total solids in solution exceeding 500 parts per million are high. For boiler use, water may be termed bad if total incrusting and corroding constituents exceed 250 parts per million. For irrigation use the relative harmfulness of the

common alkalis may be expressed as follows: sodium sulphate 1, sodium chloride 5, sodium carbonate 10. The total amount allowable depends upon the individual crop.

In cases where no alternative source of water is available, methods are in use for improving certain types of mineralized water, but these are not always satisfactory and are usually costly. If there is possibility of overdraft from an aquifer, consideration should be given to the future increase of mineralization. This is most likely to occur in older alluvial or sedimentary rock formations, as it did in the Lindsey-Strathmore District in California, although it may occur in modern alluvium, if there is stagnation in ground water circulation so that accumulated storage is drawn upon from considerable depth, or if the aquifer is adjacent to a body of mineralized water such as the ocean. The lowering of the hydraulic grade below sea level by excessive pumping, so as to cause a back flow from salt water, will not only render pumped water temporarily unfit for use, but may ruin the supply permanently because of the slowness with which leeching occurs upon the return of normal conditions. The hydraulic grade and ease of transmission of water through the formation in contact with the salt water are the important elements to be considered.

Modern irrigation experience indicates that more attention must be given to the effect of moderate mineralization of water upon soil and crops after a long period of years and the use of ground water for irrigation purposes should be carefully considered from this standpoint.

The possibility of bacterial pollution is of special importance to water works men and no selection of an underground water supply should be made without a careful sanitary survey of the intake and catchment areas of the aquifer for possible sources of pollution and the possibility of their removal or correction. This is particularly true of supplies from shallow wells, springs or from fractured or jointed sedimentary or crystalline rocks. It is important in this connection to recognize the fact that the intake and catchment areas of an aquifer may not be limited to the surface drainage area of one stream but may include land tributary to several streams flowing in different directions. The writer had several interesting experiences in this connection in northeastern France in locating the source of observed pollution in springs issuing from fissured limestone. The immediate locality and catchment area were free from

sources of pollution and it was only after a study of the local system of structural faulting which was responsible for the fissured condition of the rock that the source was discovered. Pollution, sometimes shown by analysis of water from drilled wells drawing from underlying strata, is usually occasioned by leakage of surface water into or around the casing, although there is the possibility of bacterial life in the moisture adhering to the casing above the water level.

Relative elevation

Consideration should not only be given to the relative elevation of the point of issue of the supply at the surface and the point of use, but also in case of a well development of the drawdown during operation. The location of a well to reach a given water bearing formation may often be varied without affecting the developed supply. That location should be chosen which, other things being equal, will in the long run involve the least cost. In general, it is cheaper to raise water above ground than from below the surface. It is not always cheapest to locate a well on a high spot in order to have gravity delivery. An interesting exception to this rule occurs in the Roswell district in New Mexico, where the artesian pressure is sufficient to produce large flows at the surface of the ground even at the top of knolls. One well located in this district may often serve several adjacent tracts of land by gravity.

Legal access and control of land

This is not a technical question, but it is a very important consideration in selecting the location of ground water development. The area of land required may be simply a few acres for a pumping lot, or sufficient to protect the immediate surroundings of a spring or gallery, or it may extend to a considerable portion of the land overlying the aquifer. The latter condition may result either from the necessity of protection against sources of pollution, or to permit of heavy pumping draft, affecting water levels over a wide area. The cost of acquiring such control must usually be considered in locating a source of supply.

Interference with other developments

The probability of a ground water development interfering with existing or prospective development by others from the same aquifer

is remote in humid regions. Under semi-arid or arid conditions, however, it is of frequent occurrence and in a settled locality should be carefully investigated before selecting a site.

The law of underground waters, as established by English decisions, classifies percolating water as real property, part of the soil or rock, just as building stone or mineral deposits, and the owner of the overlying land may do as he pleases with the water, without regard to the effect upon his neighbor. Although this rule was originally recognized in American decisions, there has subsequently been a change. Percolating water is now regarded as a common supply which becomes private only when taken into physical possession. Under the American rule, as amplified by California decisions,the right of use is confined to land having natural access to the supply, each land owner being entitled to a reasonable use on his own overlying land in conjunction with equal and correlative use by other land owners having access to the supply, except as affected by prescriptive use, etc. Under this rule, diversion of percolating water from a pumping lot for municipal or other use of a distant point might be enjoined through complaint of adjacent land owners, if proof could be presented of actual damage to the land or its value, present or future, or impairment of rights in a water course. The importance of investigating the site with reference to the possibility of interference as a result of contemplated development, therefore, is obvious.

The above lines of investigation are the most important in the selection of a source of ground water. When a satisfactory source has been selected, the next step is to determine upon a method of development.

TYPES OF DEVELOPMENT

Ground water may issue naturally from an aquifer as a spring or it may be developed artificially by means of wells, tunnels or infiltration galleries. Even in the case of springs it is necessary to do a certain amount of development work. The method of development of ground water and the manner in which such work is executed are of importance in securing a satisfactory and permanent supply at least cost.

Springs

Springs may issue either from an opening in more or less impervious rock or from the exposed edge of a bed of unconsolidated

material. It often happens that the point at which a spring issues from rock is buried or choked with loose material and soil and the real character of the spring is not apparent at the surface. In such instances the flow of the spring is diminished or dissipated and local pollution of the water may result. The development of a spring consists of clearing away superficial material so as to expose the point of issue from the rock or saturated bed and the construction of a covered basin which will prevent the choking of the outlet and insure protection from local pollution. Provision for disposal of surface drainage is also important. In case of a spring issuing from unconsolidated material, it is often possible to increase the flow by the construction of collecting drains leading the water to a central basin. The writer observed a number of springs in France, once wet spots on sloping ground, which had been thoroughly developed by drains and a central covered collecting basin below the ground surface, the whole recovered with soil and cultivated as part of a large tract and the water led to a nearby village where it formed the principal supply. Small springs are of frequent occurrence in the hill and mountain sections of California, but it is seldom that one is found developed in a permanent manner so as to use the maximum available supply. Neglect of provision for protection from pollution is especially noticeable.

An interesting example of municipal water supply derived from springs is that of the city of Paris from the upper Vanne springs. The aquifer is composed of broken chalks overlaid by more or less alluvial material and lying upon impervious marl. It receives a precipitation of 28 inches annually. The chalk underlies the whole catchment area of 36,300 acres and practically all precipitation is absorbed without producing surface runoff, the water appearing lower down in several groups of springs. These have been developed and collected and conducted to Paris by closed conduit 108 miles in length. The water is not exposed to daylight from the time it is absorbed by the formation until it reaches the consumer. The average total yield is 24.5 cubic feet per second which is about 21 per cent of the average annual precipitation.

Tunnels and galleries

The use of tunnels or infiltration galleries for the purpose of developing underground water is not advisable except for very

stable water table conditions. Tunnels penetrating porous aquifers which lie mostly above the tunnel section, such as that of the City of Santa Barbara, through the Santa Inez range, and the Waiahole tunnel on the island of Oahu, Hawaii, are often successful and sometimes productive. In Southern California several tunnels were driven in the early days of water development, penetrating coarse alluvial material. The yield has usually been found to vary widely following the meteorolgical cycle and to be least during periods of drought, when most needed. The volume is also small as compared with the yield of wells drilled and pumped with modern methods and equipment.

The use of infiltration galleries is largely confined to the clarification and collection of surface water, such works being located in open alluvial material adjacent to flowing streams or reservoirs. There are numerous examples of such both in America and Europe, among which might be mentioned the Sunol filter galleries of the Spring Valley Water Company, the galleries in the bed of the Los Angeles River producing part of the supply for the City of Los Angeles, the galleries of Nancy, Lyons, Toulouse, Angers and other cities in France.

The use of galleries to intercept ground waters is much more common in Europe than in America. Many cities in Holland, Belgium and Northern France, successfully obtain their supply in this manner. The conditions favorable for such a type of develop-

Yield of infiltration galleries

CITY	TOPOGRAPHY	GEOLOGY	ANNUAL RAINFALL	CATCHMENT AREA	AVERAGE YIELD OF GALLERY	
					Sec. ft.	Per cent of rainfall
			inches	*acres*		
Rennes	Gently sloping, broken by small valleys cultivated	Decomposed granite in place	35	8220	9.8	29.5
Brussels	Gently sloping, broken by small ravines, cultivated	Porous sand	27.6	8960	8.3	29.4
Brussels	Same, forested	Same	27.6	2250	2.6	37
Liege	Gently sloping ground	Fissured white chalk	31.0	8780	5.7	18.1

ment are an aquifer of considerable area but small depth, composed of material through which water does not move rapidly, the supply being from surface water applied generally and more or less continuously over the surface of the aquifer so as to maintain a constant level of the water plane. Either irrigation or rainfall continuous throughout the year are favorable conditions for recharging the aquifer. A recovery of 30 per cent of the annual rainfall upon the catchment area is not unusual in Holland. Similar results are obtained in Belgium and France as indicated by the table on preceding page.

Wells

The most common method of developing ground water in America is by means of wells. The advantage of the well is that, at relatively small cost, it may be constructed so as to embrace a wide range of possible fluctuation of the water table. It is the only method by which deep aquifers may be reached. With the advance in the manufacture of well pumping equipment which has taken place during the past fifteen years, the depth from which water may be efficiently pumped and the pumping yield of small diameter wells in open formations have been greatly increased. The standard of efficiency also has been increased and the relative cost has been reduced for all classes of service. This has greatly extended the field successful well development.

Wells may be broadly classified as open or tubular. The open well is large enough to allow a man to enter it and descend to the water level. This type is usually dug and has a minimum width or diameter of two feet. Ordinarily no special equipment or highly specialized labor is required for its construction. It is especially adapted for use where the depth to the water table is small, excavation not difficult and the yield of a single well sufficient to furnish the full supply. Its advantages result from the large interior surface area and the storage capacity, both of which tend to increase the pumping capacity. In cases where the material stands well, the yield of a dug well may be increased materially and at small cost by tunneling or boring laterally from the bottom. Tests made by the writer in San Diego County, California, indicate that the yield, of a dug well in decomposed granite may be more than doubled by several hundred feet of two inch auger borings extending radially to a distance of 60 to 130 feet from the bottom of the well. In

boulder formations, where it is impossible or costly to sink a well by ordinary drilling methods, the dug well type is often adopted with success.

The tubular well is circular and too small to allow the entrance of a man. Tubular wells are seldom greater than two feet in diameter. The method of sinking is usually by drilliug, although for domestic supply, wells of this class are often driven or bored. Drilled wells are excavated either by the percussion or rotary process. In the former, the drill consists of a cutting bit at the end of a string of tools suspended by a steel cable or hemp rope, which is alternately raised and lowered by means of a spudding device or walking beam and breaks up the material at the bottom of the hole. The cuttings are removed either by means of a bailer or hydraulic circulating system.

In the modern rotary process the material is loosened by means of a heavy line of rotating hollow drill rods with a fish-tail or other type of cutting bit at the lower end. Cuttings are removed by forcing a stream of water through the rods to the drill where they are picked up and carried to the top of the hole. When passing through caving material, the walls of the hole are firmly plastered with clay, carried by the circulating water. After completion of drilling, screw-joint casing of uniform diameter is set in the well with perforated sections or well screens opposite the water bearing strata and the clay is removed. The latter process, called "developing the well," is accomplished by various processes of washing, jetting, churning and pumping with air or a centrifugal pump.

For consolidated materials the percussion drill method, cable system, is the most commonly used in America for water wells. Either the standard outfit used in the oil industry or a portable outfit may be used, but as depths of 1500 feet may be reached with the latter, there is seldom occasion to use the standard outfit in drilling for water. Several American firms manufacture good portable rigs of varying sizes, both steam and gasoline operated. The former is usually favored by drillers as it gives greater flexibility of operation and is more reliable.

For drilling in unconsolidated materials, several methods are employed. One which is particularly adapted to use in non-caving glacial drift or alluvial deposits where sand, heavy gravel or small boulders are encountered with or without layers of clay, is the "stove and pipe mud scow" or "California" method. Holes from 6 to 30

inches in diameter may be drilled by this method and, under favorable conditions, depths of 1000 feet may be attained although 600 feet is ordinarily the limit. A horse-drawn, portable rig, mounted on wheels and operated with gasoline engine power, is used. Material is broken up by means of a cutting shoe or clay bit at the bottom of the bailer or sand bucket. The latter is suspended by a steel cable and alternately raised and lowered by the reciprocating motion of a walking beam at the top of a derrick. Material is removed by means of the sand bucket which has a flap valve at the bottom and is filled simultaneously with drilling operations. Stove pipe casing with a starter at the bottom, is sunk as rapidly as the hole is advanced by means of hydraulic jacks and perforated subsequently at water bearing strata. This method was developed in Southern California for drilling in soft alluvial material and the rig is manufactured by local firms in that region.

For unconsolidated, fine texture material, such as clay, sand or quicksand, which has a tendency to cave, the rotary method is best. It requires skilled operators to insure success, and careful observation to determine the location and thickness of water bearing strata. The process of developing the well especially requires experience and judgment, many poor wells or failures being due, not to the formation, but to the lack of skill of the drillers. Most rotary drillers gain their experience in the oil fields where the problem is to shut off the water. Drilling for water requires modifications in rotary drilling practice which are only learned by experience.

For unconsolidated materials, consisting mostly of large boulders where an open well is not advisable, the percussion drill method is being used with success in certain districts of California.

The possibilities of the percussion drill method in sinking wells, where occasional strata of caving material are encountered, were well illustrated by the work of the American drillers in France during the war. The region of Tours in the Loire Valley, has several strong artesian horizons at a depth not exceeding 600 feet, but several of the strata encountered in drilling have a tendency to cave badly. A number of successful wells had been drilled in this region by French contractors, but in all cases great delay resulted in trying to pass through the caving formations. The period consumed in drilling operations was anywhere from six months to three years and, in some instances, enormous quantities of material were taken from the well. An American "oil country" crew, with

a portable rig, drilled a well in similar formations in this region to a depth of approximately 600 feet in three weeks, passing through the caving formations without trouble. The difference in drilling time was apparently due to continuous operation. The French crews worked a short eight hour day with much time off for repairs, setting casing, etc., while the American crew actually drilled 24 hours per day, keeping the casing close behind the drill, and the material had no opportunity to work into the hole.

The great increase in the number of wells drilled during the past ten years has created a background of accumulated experience which, if made available, would be of great value to water works officials and hydraulic engineers. As an example we may mention the development of successful methods of obtaining producing wells in fine, sandy, alluvial deposits, such as occur along the California coast, by jacketing the casing with gravel. This is being accomplished, either by first sinking a large diameter, perforated, outside casing and filling the space between it and the inner casing with coarse sand and gravel, as at the wells which supplied the San Francisco Exposition grounds in 1915, or by placing gravel around the outside of the casing at the surface and allowing it to settle as fine material is pumped from the well until the casing is completely surrounded, as is frequently done in the coastal valleys of San Diego County, where the formation is entirely loose sand or gravel

Although the subject of ground water as outlined above has been presented in a sketchy manner, it is believed that it will be of suggestive value to water works officials who may be faced with ground water problems.

THE CLOGGING OF SCREENS BY FISH[1]

By Leonard Metcalf[2]

In designing a new 54-inch intake and supply conduit for the Portland, Maine, Water District, to bring water from Sebago Lake into, and thus increase the capacity of, the supply pipe system, the writer chanced to encounter the fish problem in an interesting way. During the spawning season considerable difficulty had been experienced at certain times in the screen chamber and as engineering literature upon the subject was meagre, the actual experience in the past with the old intake pipe was investigated, as the best evidence upon which to predicate the new design. These data are now presented to this Association, in the hope that they may call forth the experience of others with fish in their screen houses and the methods used for mitigating or removing the difficulties.

OLD INTAKE AND SUPPLY CONDUIT

The old intake, consisting of about 480 feet of 48-inch cast iron pipe, was laid in 1898 from the gate house to the inlet, which is 450 feet from the shore line of the lake. The pipe was laid in trench, under cover, for a distance of about 264 feet from the shore, at which point the depth of water over it is from 7 to 8 feet, under average water conditions, and 3½ feet at legal low water limit.

The end of the intake consists of a 48-inch by 48-inch by 48-inch tee pointing up, laid on the bottom of the lake, with the top of the bell of the intake 14 feet under water at mean lake level, and 10.5 feet at the legal limit for low water. The bottom is covered with large boulders and there is little, if any, growth on the floor of the lake at this point. The 48-inch intake enters the gate house into a chamber 7 feet long by 8 feet wide, unfortunately at a slight angle (about 25 degrees) with the axis of the chamber.

At a distance of 7 feet from the point of entry the water passes the screens. These screens are in duplicate, with little cages at the

[1] Presented before the Detroit Convention, May 24, 1923.

[2] Of Metcalf and Eddy, Consulting Engineers, Boston.

bottom to catch the refuse as the screens are raised to clean them. In the cleaning one set of screens and then the other is raised, cleaned and replaced, so that ordinarily the water passes through two sets of screens. Each of the screens consists of a series of units placed one on top of another, sufficient in number to cover the water section from the under side of the inlet pipe, to high water in the lake, a distance of something over 10 feet.

The screening units have wooden frames of 1 inch by 3 inch lumber bolted together with copper wire mesh secured between them. The screen area is cut in two by a midrib of 1 inch by 3 inch stock. Each screen unit, 7 feet 3 inches by 27 inches has a gross wire mesh area of 11.375 square feet, or a net water area of 7.45 square feet, equivalent to 65.52 per cent of the gross wire area. The mesh is of copper wire 0.065 inch in diameter, 0.355 inch on centers longitudinally and 0.328 inch transversely.

As stated, the water from the lake enters the screen house unfortunately at a slight angle from the normal to the screen, which prevents uniform rectilinear flow to the screen and equal distribution of velocity in the threads of the stream and causes the main current to impinge against the wall diagonally opposite the opening and to flow thence towards the further end of the screen instead of towards its midsection.

EXPERIENCE WITH FISH

The writer visited the screen house, with Mr. Harry U. Fuller, Chief Engineer of the Water District and the Resident Foreman, Mr. Marshall Higgins, at 8 p.m. January 22, 1923. The evening was clear and cold. The lake was covered with ice, with a 2 foot mantle of snow upon it.

There were relatively few fish in the gate house, above the screens, perhaps 2 quarts in volume and several hundred in number. The fish varied in length from 3 to 4½ inches, the thickness of the body being from 1¼ to 1½ inches. When the screens were removed about one quart of fish were taken from the baskets upon them. There were removed in the course of the 24-hour period 2½ quarts of fish. The fish were of a smaller type than those which run up to the lake to spawn. The latter are usually from 10 to 12 inches in length. The fish taken here were apparently mature, however, because well-developed spawn, in a condition about ready to be cast, was found in a number of fish, varying from 3½ to 4½ inches in length. The fish

appeared to swim readily against the current, and were not drawn up against the screens to any great extent. Yet the dead fish in the baskets indicated that they had been drawn against the screens and drowned before they were able to get away from them. The irregular flow of the water in the screen house, with the boiling tendency referred to, was indicated by the way in which the fish rolled up from time to time with the current from the greater to the lesser depths, showing their flashing bellies, apparently unable to maintain their vertical position.

Mr. Higgins stated that trouble was experienced with the fish generally during a three months' period from December 15 to March 15, though the run of fish had sometimes begun as early as the latter part of November and continued for a longer or shorter period than that referred to above. He was of the belief that the worst conditions were found immediately before bad storms even with ice and snow on top of the water.

The worst experience, he said, was had in the winters of 1904–5 and 1910–11, when one or two bushels of fish were taken out in a 24-hour period, instead of a few quarts. During one of these periods the clogging of the screens by the fish was so serious that on one occasion the screens were actually burst and the fish which came through gave serious subsequent trouble in the pipes. During more or less of the three months' period referred to, it has been the custom to visit the screens at frequent intervals during the day and more recently, as during the past year and this winter, to have a man in the screen house throughout the night, netting the fish and removing them from the screens, as a precautionary measure to prevent serious clogging. Mr. Higgins was of the opinion that there had been one or two nights in which, had there not been a man present, there might have been serious trouble from the clogging of the screens.

The recent trouble was probably due to two facts (1) the increased rate of water consumption of the present as compared with the past, and (2) the present low water level of the lake.

The record of water levels in Sebago Lake was subsequently examined carefully, particularly with reference to the minimum levels during the months stated (December 15 to March 15) in the period of years from 1904 to date; and the mean daily consumption was determined as nearly as possible. These data were then studied with reference to the conduit capacity, the actual net water area of the screens at different levels, and the maximum hourly water consump-

tion, based upon an assumed maximum 50 per cent in excess of the mean daily consumption during the year. The result is interesting. It indicates the reason for the conditions reported by Mr. Higgins as having been observed in the years 1904–1905 and 1910–11 (see table 1).

In the first instance the trouble was clearly due to low water level in the lake (El. 261.5), though in this connection it is to be borne in mind that the present minimum legal low water level is above this (El. 262.5) and that the water is not likely again to reach the observed low level.

TABLE 1

Water demand and effect of lake levels on conduit capacity

YEAR	PORTLAND WATER CO. CHART, LAKE SEBAGO ELEVATION DECEMBER 15 TO MARCH 15	MINIMUM LAKE LEVEL	CONSUMPTION		CONDUIT CAPACITY AT STATED MINIMUM LAKE LEVELS	VELOCITY FPS. THROUGH SCREENS (WATER AREA) WITH FLOW	
			Mean daily	Maximum hourly at 1.50 × mean daily		Mean	Maximum 150 per cent
					m.g.d.		
1904–05	262.3– 261.6	261.5	7.2±	10.8	6.3	0.8	1.2
1905–06	262.1– 263.1	262.1	7.4	11.1	9.0–	0.8	1.1
1906–07	262.3– 262.3	262.3	7.6	11.4	9.0+	0.8	1.1
1907–08	265.7– 266.7	265.7 '08	7.7	11.5	18.0+	0.4	0.7
1908–09	263.3– 264.1	263.3	8.0	12.0	13.0	0.8	1.0
1909–10	263.9– 263.6	263.4 '10	8.4	12.6	13.0	0.7	1.0
1910–11	262.5– 262.5	262.3	8.6	12.9	9.3	0.9	1.3
1911–12	263.3– 263.2	263.1 '12	8.8	13.2	12.0+	0.7	1.1
1912–13	265.1– 264.8	264.8	9.0	13.5	17.0	0.6	0.9
1913–14	264.4 { 263.9+ / 265.3 }	263.9 '14	9.2	13.9	14.7	0.6	1.0
1914–15	263.6– 263.8	263.2	9.5	14.2	12.7	0.8	1.2
1915–16	264.2– 265.5	264.2 '16	9.8	14.7	15.5	0.7	1.0
1916–17	266.4– 266.2	266.2	10.0	15.5	18.9	0.5	0.8
1917–18	266.5– 265.4	265.4 '18	10.3	15.4	17.8	0.6	1.0
1918–19	266.5– 268.2	266.4 '19	10.6	15.9	19.1	0.6	0.8
1919–20	266.2– 265.2	265.1 '20	10.8	16.2	17.4	0.7	1.0
1920–21	266.2– { 267.7 / 268.2 }	266.2 '21	12.5	18.7	18.9	0.7	1.0
1921–22	265.0– { 264.4 / 264.9 }	264.4 '22	13.0	19.5	16.0	0.9	(1.3)
1922–23	264.8	264.8 ?			17.0	0.8+	(1.2)

Average low elevation 264.12
Low level water elevation 262.5

TABLE 1—*Continued*

Old conduit capacity based upon Hale's gagings (see p. 5 Hazen's report of June 24, 1009. BM—Mean Low Tide which is comparable with Legal Low Water Sebago Lake Elevation 262.5)

Million gallons daily	ELEVATED WATER SERVICE			FEET LOSS IN HEAD	
	Sebago Lake	Inlet chamber	Manhole 1	Screen to manhole 1	Intake
5	261.10	261.06	257.3±	3.8	+0.04 = 3.8
6	261.40	0.34		4.0	+0.06 = 4.1
7	0.68	0.59	257.4	4.2	+0.09 = 4.3
8	0.94	0.83		4.3	+0.11 = 4.4
9	262.20	262.06		4.5	+0.14 = 4.6
10	0.45	0.27	257.6	4.7	+0.18 = 4.9
	262.5—Legal low water				
11	0.72	0.51		4.8	+0.21 = 5.0
12	263.05	0.80		5.0	+0.25 = 5.3
13	0.37	263.07		5.2	+0.30 = 5.5
14	0.70	263.35		5.4	+0.35 = 5.8
15	264.05	0.65		5.7	+0.40 = 6.1
16	0.37	0.92		5.9	+0.45 = 6.4
17	0.80	264.29	258.1	6.2	+0.51 = 6.7
18	265.55	0.98	258.2	6.6	+0.57 = 7.2
19	266.30	265.66	258.3	7.2	+0.64 = 7.8
20	267.00	266.29	258.4	7.8	+0.71 = 8.5
30	267.7		258.7	9.3	

The trouble on the second occasion, 1910–11, was due to the combined effect of low water (El. 262.3) and the relatively higher rate of consumption in that year (8.7 m.g.d. as compared with 7.2 m.g.d.).

The trouble during the last two years has been due to the increased consumption, (which has averaged 13 m.g.d. with a maximum of 20 m.g.d.) rather than to the lake level, the lowest level of which was El. 264.4 in 1921–22, and El. 264.8 in 1922–23.

The developed facts indicate that, when the mean velocity of flow through the water area of the screen, based upon the mean daily water consumption of the year, reaches an amount of 0.8 of a foot per second, or exceeds it, and when the maximum rate of flow through the water area of the screens, based upon an assumed maximum rate of 50 per cent in excess of the mean daily rate during the year, is equal to 1.2 feet per second, or more, serious trouble has been

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	Sebago Lake	Inlet chamber	Manhole 1	Screen to manhole 1	Intake
5	261.10	261.06	257.3±	3.8	+0.04 = 3.8
6	261.40	0.34		4.0	+0.06 = 4.1
7	0.68	0.59	257.4	4.2	+0.09 = 4.3
8	0.94	0.83		4.3	+0.11 = 4.4
9	262.20	262.06		4.5	+0.14 = 4.6
10	0.45	0.27	257.6	4.7	+0.18 = 4.9
	262.5—Legal low water				
11	0.72	0.51		4.8	+0.21 = 5.0
12	263.05	0.80		5.0	+0.25 = 5.3
13	0.37	263.07		5.2	+0.30 = 5.5
14	0.70	263.35		5.4	+0.35 = 5.8
15	264.05	0.65		5.7	+0.40 = 6.1
16	0.37	0.92		5.9	+0.45 = 6.4
17	0.80	264.29	258.1	6.2	+0.51 = 6.7
18	265.55	0.98	258.2	6.6	+0.57 = 7.2
19	266.30	265.66	258.3	7.2	+0.64 = 7.8
20	267.00	266.29	258.4	7.8	+0.71 = 8.5
30	267.7		258.7	9.3	

The trouble on the second occasion, 1910–11, was due to the combined effect of low water (El. 262.3) and the relatively higher rate of consumption in that year (8.7 m.g.d. as compared with 7.2 m.g.d.).

The trouble during the last two years has been due to the increased consumption, (which has averaged 13 m.g.d. with a maximum of 20 m.g.d.) rather than to the lake level, the lowest level of which was El. 264.4 in 1921–22, and El. 264.8 in 1922–23.

The developed facts indicate that, when the mean velocity of flow through the water area of the screen, based upon the mean daily water consumption of the year, reaches an amount of 0.8 of a foot per second, or exceeds it, and when the maximum rate of flow through the water area of the screens, based upon an assumed maximum rate of 50 per cent in excess of the mean daily rate during the year, is equal to 1.2 feet per second, or more, serious trouble has been

experienced from time to time with these fish under the conditions described as prevailing in this screen house.

It may well be, however, that if the 48-inch cast-iron pipe, at its entrance into the gate house, had been so located as to discharge at right angles to the face of the screens, the trouble would not have been experienced, certainly at such low mean velocities as those stated, because the velocity of approach to the screen would have been much more uniform than it is under existing conditions.

It would be prudent, if practicable, in designing the screens for the screen house upon the new conduit, to keep the velocity of flow through the water area of the screen down to *0.5 foot per second, based upon the mean daily consumption during the year.* In this connection, it is to be borne in mind that the water section of the ordinary woven wire screen is approximately two-thirds of its gross area, and of the punched metal screens not over one-half, and in some punched metal as little as one-fourth.

COMMENTS UPON THE CHARACTER AND HABITS OF THE AMERICAN SMELT

Diligent inquiry concerning the species of the fish taken from the screen house, and of their habits, elicited the following information from Mr. O. C. Bourne, Chief Warden of the Massachusetts State Department of Conservation, Fish and Game.

The fish undoubtedly are American smelt, *Osmerus mordax* (Mitchell). There are two different varieties of smelt; the large variety called "smelt" or "blue-backs" and the small or the "land-locked smelt." The latter variety are sometimes called "gray backs" and are usually found in fresh water streams and ponds. Blue-backs have been found in Weir River, Hingham, which weigh ¼ pound and measure 12 inches in length.

The natural tendency of the smelt is to go to fresh water during the winter months, to cast their spawn. They are more affected in spawning by the temperature of the water than by any other factor and will often go up the stream each night for four or five consecutive days until they find the temperature of the water just right. The first part of the spawning run takes place at about 10 p.m. and lasts until 3 or 4 a.m., during which time the temperature is best for spawning. The fish will not stay longer than two or three days at the most in the ponds or streams and then return to salt water, if possible.

The spawn does not fully develop until it gets into fresh water; there it develops very quickly.

The fish hatched sometimes adapt themselves to fresh water conditions and grow to be larger than the salt water variety. This adaptation, however, does not last long, as the fish seem to become smaller and smaller each successive generation, and finally after six or seven years most of the fish die by epidemic. If spawn taken from fish, that have adapted themselves to fresh water conditions but are in the stages of this process of degeneration, are transferred to new streams such as the Berkshire Streams in Massachusetts, where they would not normally be found, the fish hatched become normal in size and again thrive, only to degenerate in later generations and die during an epidemic.

The natural tendency of the fish hatched in fresh water is, however, to seek salt water and again return to fresh water only to spawn.

They generally try to spawn near a riffle where there is gravelly soil. If they are in a fresh water pond trying to spawn and if there are no small inlet or outlet streams, about 90 per cent will try to spawn along the shore.

With regard to the particular problem at Sebago Lake, Mr. Bourne said there was no question in his mind but that the specimens submitted were of the fresh water variety (land-locked smelt) or a variety that have pretty nearly run out. If they are land-locked smelt, they would not be much larger than these specimens.

He said it was natural to expect more of them between December and March, as this was the time of spawning. The probable reason for finding the large number in the gate house was that they entered the 48-inch pipe with the flowing water, seeking proper grounds for casting spawn. He thought, undoubtedly, that large quantities of the fish would be found in the small streams entering the lake during the same time they were found in the pipe.

Mr. Bourne had no knowledge as to the current against which a smelt could swim, but said that he had seen them in fast moving streams.

Extracts from "American Food and Game Fishes" (by Davis S. Jordan and Barton W. Evermann).

"American Smelt. *Osmerus mordax* (Mitchell)."

"This is the Smelt of America. It is found along the Atlantic Coast from Virginia to the Gulf of St. Lawrence, entering streams and is often land-locked. It is abundant in Lake Champlain and Memphremagog and in many other lakes

of New England, New Brunswick and Nova Scotia. It enters our rivers and brackish bays during the winter months for the purpose of spawning." * * * * * * *

"The principal food of the smelt consists of shrimps and small crustations.

" Color, transparent, greenish above, sides silvery; body and fins with some dark punctuations. The smelt does not usually exceed 8 or 10 inches in length, but it sometimes exceeds a foot in length and a weight of 1 pound.

"Examples from Sebago Lake recently obtained (book published in 1902) by Dr. Kendall[3] measured 12 inches in total length and even larger ones occur in the Belgrade Lake of Maine.

"In Wilton Pond, Kennebec County, Maine, is a land-locked smelt which has been recognized as a sub-species of the common smelt under the name Osmerus mordax spectrum. It seems to be distinguished by a somewhat shorter head and more slender body.

"In Cobbosseecontee Lake, Maine, is found another sub-species, O. mordax abbotti, which has the head still shorter and the body more slender; maxillary reaching posterior margin of pupil.

"These sub-species are of doubtful validity."

CONCLUSIONS RELATIVE TO INFLUENCE OF FISH

It appears reasonable to conclude:

1. That it is desirable to keep the velocity of flow through the water section of the screens down to 0.5 foot per second, on the basis of the mean daily flow during the year;

2. That this limit may be substantially exceeded if the velocity of approach is uniform and normal to the screen face;

3. That if the approach to the screens be rectilinear and the velocity fairly uniformly distributed in the section and if the flow be *parallel to the face of the screens* as the water passes through the screen chamber up to the point of passage through the screens, thus tending to make it much easier for the fish to keep clear of the screen surface, higher velocities can probably be used with safety.

[3] Dr. Wm. C. Kendall of Syracuse University, Syracuse, New York, who has given much study to the fish of Sebago Lake.

STRAY CURRENT ELECTROLYSIS[1]

By E. R. Shepard[2]

The subject of stray current electrolysis has not found as frequent place in the annals of the American Water Works Association during recent years as the importance of the subject might warrant. Obviously this topic is not a particularly popular one with the street railways, and they have not gone out of their way to stimulate interest in it, but just why water and gas engineers and operators are indifferent to it, as many of them undoubtedly are, is a question worthy of analysis. Several reasons for this are suggested. Possibly the gradual and general improvement which has taken place in street railway operation and engineering since the early days has so greatly improved conditions over those formerly existing that the pipe owning companies and operators are content to let well enough alone and have learned in one way or another to repair and retard damage so that the losses are no longer excessive and are tolerated as a regular part of the maintenance on the system. Possibly in some locations they have become weary of a long and losing fight against the distributors of stray currents and have given up the hope of getting any redress or action from that source. To reflect thus upon the attitude of the street railways, however, requires some qualification, for, as a rule, they have recognized the problem and have taken reasonable steps to overcome or mitigate electrolysis. As a matter of fact in most large cities stray currents have been reduced to such an extent that the damage now in progress is small in comparison to that which developed soon after the advent of the electric railway. At that time, before the art of rail bonding had been developed, stray currents ran rampant and caused such wholesale destruction that some engineers predicted that pipes could not be maintained in the ground unless the street railways adopted the double trolley or went out of business altogether.

[1] Presented before the Illinois Section meeting, Decatur, March 21, 1923.

[2] Consulting Electrical Engineer, Chicago, Ill.

The action now is less acute and therefore harder to locate and recognize. In fact, it is often impossible to distinguish between stray current electrolysis and soil action and the most experienced expert is sometimes at a loss to diagnose a case of pipe corrosion. This condition alone is often a source of great embarrassment to the water or gas engineer, who, unfamiliar with the laws of electricity and electrolysis, is told by the street railways that his trouble is the result of corrosive soil and in no way due to stray currents. Not being in a position to prove his case and not being highly encouraged by litigation and investigations in other cities, he is forced to repair his damage at his own expense and swallow his wrath. The difficulty in identifying electrolysis, the uncertainty in interpreting electrolysis data, the conflicting opinions held by experts regarding methods of mitigation, and the other innumerable factors which enter into the problem are all so confusing and bewildering, even to those who have studied the subject, that there is little wonder if the operator throws up his hands in helplessness, or takes a seat on the side-lines to watch developments in other quarters or to await a grand solution by the American Committee on Electrolysis.

In analyzing the attitude of the utility operator, however, we should not forget the man, and let us hope that he is in the majority, who is really having little or no trouble from this annoying source, and who for this reason manifests no particular interest in the subject.

WORK OF THE AMERICAN COMMITTEE ON ELECTROLYSIS

Although electrolysis damages are far less prevalent than they were a number of years ago, more research work is now under way and more is being done to arrive at an ultimate solution of the problem than ever before. The principal work of this character is being carried on by the United States Bureau of Standards in cooperation with the American Committee on Electrolysis. This committee, composed of representatives of the several National Utility Associations and Organizations, was formed several years ago and issued in 1916 its first report which treated only of Principles and Definitions, American Practice and Foreign Practice. It was of comparatively little assistance to the utilities, as no standards were established and no controversial matter was admitted. During the period of the war the committee was in a state of suspended

animation, but in 1919 it was reorganized and immediately entered into active coöperation with the Bureau of Standards and upon the preparation of a second report. A sub-committee was formed known as The Research Sub-Committee with one representative from each member association. The duty of this sub-committee was to coöperate with the Bureau of Standards in carrying out field and laboratory studies along controversial lines and other phases of the problem on which it was felt that additional information was needed.

For years pipe drainage had been and still is a subject on which engineers and operators had strong differences of opinion, and the research work determined upon was therefore directed along such lines as would tend to throw light upon this method of electrolysis mitigation. As joint electrolysis, or corrosion at pipe joints, was admitted to be one of the chief arguments against pipe drainage, this subject was selected for first consideration. The entire spring and summer of 1920 were devoted to tests and examinations to determine the seriousness and prevalence of joint electrolysis and its relation to the electrical drainage of pipes. Studies were made in Denver, Kansas City, St. Louis, East St. Louis and Cleveland. The work was carried on chiefly under the direction of engineers of the Bureau of Standards, but members of the committee made frequent visits and inspections throughout the course of the investigation. It is unfortunate that, after all the work that was done and the many subsequent conferences, the committee was unable to agree upon a joint report of its findings that was of any material benefit to the utilities. The only statement concerning this subject that was made public is to be found in the 1921 report of the main committee, reading as follows:

> High resistance joints are prevalent in all jointed pipe lines and they greatly complicate the application of drainage.
>
> To lower the potential of a jointed piping system below that of the surrounding earth, it is usually necessary to extend the drainage conductors over a considerable area and connect to the pipes at numerous locations.
>
> Corrosion at high resistance joints in pipe lines carrying current may occur unless the pipe on both sides of the joint is maintained negative or neutral to the adjacent earth, in which case no corrosion will occur.

The 1921 report of the American Committee went somewhat further than the 1916 report in discussing pipe drainage and other methods of mitigation, but, since it represents the unanimous opinion

of the members, many statements were of necessity guarded and indefinite. In concluding its report, the committee admitted the need of further information along many lines and set up a program of research to be jointly pursued by its Research Sub-Committee and The Bureau of Standards. Among the subjects enumerated are the following:

1. The development of improved methods of testing by which electrolysis conditions can be more definitely and accurately determined than by the methods of test now in common use.
2. Studies of electric railway power distribution.
3. Study of mitigative measures applied to affected structures.
4. Soil corrosion.
5. Fire and explosion hazards on gas and oil pipes.

Considerable work has already been done on this program, principally by the Bureau of Standards. The Research Sub-Committee is not actively functioning at this time owing to a movement on the part of some of the associations to discontinue the work of the main committee. It is to be hoped, however, that the interests will vote to perpetuate the committee, and that the Bureau of Standards may continue to have the support of the organization in its endeavors along this line of investigation.

INVESTIGATION CONCERNING SOIL CORROSION

Among the corrosive soils should be mentioned those containing organic acids, which are formed by the process of vegetable decay. Such soils include muck and peat and are found in the alluvial deposits of the Mississippi River and in other swampy areas. Some kinds of alkaline and so-called alkaline soils occurring in the western states and in some portions of British Columbia and Manitoba are also destructive of iron and led pipes. Salt marshes are not only corrosive to a certain degree but accelerate stray current electrolysis, because of the low electrical resistance of the earth. The same may also be said of wet, black soil containing considerable organic matter, as these are usually found to have a low electrical resistance.

Cinders, ashes and filled ground containing refuse often produce extremely acute and rapid corrosion of piping systems. This corrosion may be electrolytic in nature, resulting from galvanic action between the metal pipes and the cinders or other foreign

matter. Because of this it is difficult and often impossible to distinguish between corrosion of this character and that produced by stray currents.

Even now after years of research and investigation there remains a great deal of uncertainty regarding the causes of pipe corrosion in many instances. Corrosion is often attributed to stray current action where the soil itself is a partial, if not the sole, source of destruction. Since chemical action is primarily an electrolytic phenomenon, it is not possible to distinguish between such action and that caused by stray currents. Stray current action is often more rapid than natural rust or soil corrosion, and, in the absence of sufficient oxygen, may produce the black or magnetic oxide of iron instead of the red oxide commonly known as rust. This is really the only difference in the appearance of corroded pipes by which stray current electrolysis may be distinguished from ordinary soil corrosion, and even this test is far from reliable.

Circumstantial or contributory evidence is often to be found in the location on the pipe where the action takes place. Water and gas pipes, and particularly service pipes, often show local corrosion under street car tracks, or at points of intersection with telephone, electric light cables or other lead sheathed cables which are electrically drained to the railway negative bus and are, therefore, lower in potential than the piping systems. Where highly localized or concentrated damage is found at such intersections, the evidence is pretty conclusive that it has been caused by a discharge of stray current to the other metal structure. Where the corrosion is general and no other structure is nearby, there is always a question as to the cause of the damage even though the pipes may be positive to a car track on the same street. As a rule electrolytic corrosion of pipes is not serious except at intersections with, or close approach to, electric railway tracks or other underground structures.

The fact that gas and water services of wrought iron and steel may have shown a more rapid rate of deterioration during recent years than prior to the installation of electric railways does not necessarily throw the responsibility for such damages on the railways. The manufacturing processes by which steel and wrought iron pipes are made have undergone such changes as materially to affect their composition and structure. It is a well known fact that modern materials are much more subject to corrosion than those produced by the older methods. This condition alone is no doubt responsible for the short life of pipes in many localities.

The American Committee and the Bureau of Standards considered that further knowledge concerning the effects of different kinds of soil on the corrosion of buried metal structures was of such great importance that they selected this subject for intensive study and began active work on it somewhat less than a year ago after first enlisting the coöperation of a number of pipe manufacturing companies.

Thousands of small samples of different kinds of pipe were prepared by the manufacturers, and these have been buried in about 40 locations widely distributed throughout the entire country. All kinds of soil and climatic conditions have been included in the tests. Several samples of each kind of pipe are included in each set which will permit of unearthing them progressively over a period of years. Every sample was carefully weighed and the loss of weight resulting from soil corrosion may be determined, therefore, in an accurate and scientific manner. It is expected that positive results will be obtained in a period of two or three years and more definite results will develop as time elapses. These tests will be independent of any stray current action and are designed solely to determine the effects of different soils on different kinds of pipe, including lead, cast iron, steel, wrought iron, as well as some special materials. The whole investigation is being carried out in the most thorough manner by the Bureau of Standards and is being watched with great interest by the manufacturers and users of pipe.

The results of these experiments should be helpful in determining to what extent stray currents are responsible for the large amount of corrosion, particularly on steel and wrought iron pipes, in progress in most of our cities.

IMPROVED METHODS OF ELECTROLYSIS TESTING

It has long been recognized that the ordinary methods of testing do not give accurate information as to the hazard involved in any particular location. A potential difference measurement between a pipe and the adjacent street railway track is only one of the factors which must be known before the rate of corrosion may be ascertained. The earth resistance, the roadbed construction, the distance between the pipe and the track, and the configuration of the piping system, as well as that of the other underground structures, are all factors which affect the problem. It was with this knowledge that the committee included in its research program a study of improved

methods of testing. Mr. Burton McCollum of the Bureau of Standards had already done a great deal of experimental work along this line, and in 1921 brought out the earth current meter which was described in some detail in The Electric Railway Journal of November 21, 1921. Instead of measuring the potential difference between the pipes and the adjacent car tracks, this instrument measures directly the density of the current discharged from the pipe surface. This instrument is now available, and where the necessary time and effort are given to its application, results may be secured whose validity cannot be questioned.

Considerable experimental work has already been done with the earth current meter and the results have been most helpful in modifying and clarifying the writer's conceptions concerning electrolysis. Investigations made to date indicate that electrolytic corrosion of a serious or damaging character is usually confined to those portions of a piping network which closely approach or intersect the rails of an electric railway or other low potential structures. This idea is supported by the frequent failure of services which cross under tracks and the comparative immunity of the mains to which they connect. Of course the difference in the character and thickness of services and mains is also an important factor, but the frequent close approach of services to tracks is a condition which must not be overlooked.

INSULATING JOINTS IN SERVICE PIPES

A most promising method of protecting service pipes, subject to electrolytic damage, is by the use of insulating joints. Insulating joints in individual service pipes have not been extensively used, perhaps because no satisfactory inexpensive joint has yet been developed. Great possibilities, however, for protecting individual services which cross under tracks, and thereby eliminating the most frequent and acute cases of electrolysis, lie in the design of a satisfactory insulating joint. To be effective the service must be insulated both at the main and at the meter to insure against current entering by way of gas-water heaters. Great benefits are also to be derived from the frequent use of insulating joints in mains and the general use of high-resistance calking materials such as cement and Leadite. Care should be exercised in placing insulating joints in pipe networks in order to prevent the development of high voltage

drops across such joints. A full knowledge of the distribution and railway systems as well as of the electrical conditions is necessary in order to prevent effectively electrolysis by this method.

Time does not permit of discussing the various methods of electrolysis prevention. It may be said, however, that the matter is being given more attention by the street railway companies than it was in the past, and although in many places serious damage is still in progress, it is by no means as prevalent as it was in past years. There is also a growing spirit of coöperation between the railway companies and other utilities which enables them to handle this problem jointly and to the best interest of the public. Local electrolysis committees have been organized in a number of cities which represent the best practice at this time in electrolysis prevention.

DISCUSSION

S. L. ETNYRE:[3] It might be of interest to the members present to learn of the work that has been done to mitigate electrolysis in Council Bluffs and Omaha.

The Omaha and Council Bluffs Electrolysis Committee was organized in 1916 and is composed of representatives of all the utilities of the two cities.

The United States Bureau of Standards made a complete electrolysis survey of both cities and recommended the installation of the three wire system of distribution on trolley circuits. Nine negative trolley systems were installed which resulted in reducing the average return current at the Central Power Plant by 57 per cent and at the Lake Street Station by 85 per cent.

From tests made on eight water mains there was a reduction from 333 to 61 amperes. Underground piping and cable systems are all drained to the negative bus at the Central Power and Sub stations.

A survey, made once a year to check up conditions, consists of potential readings between underground structures, current flow in underground pipes, street railway return circuits and drainage cables. Track potentials are taken continuously through the year on 24 hour charts over telephone pairs connected to various points on the track system and run into the Electrolysis Committee office.

[3] Superintendent, Water Works, Council Bluffs, Iowa.

Over 100 charts are taken yearly, using 40 test points on the track system, thus enabling the Street Railway Company to keep a constant check on the track bonding on which a great deal of work has been done.

We used to have considerable trouble with the electrolysis of pipes along and near the Street Railway lines, especially near the Power Station, but since 1917, after this committee began to function, we have experienced little or no trouble with our water mains and services from this source.

SHALLOW WELLS AS SOURCES OF MUNICIPAL WATER SUPPLY[1]

By Earle L. Waterman[2]

Shallow wells as sources of water supply undoubtedly cause waterworks officials and health officers more concern than any other type of water supply development. Fundamentally the reasons for the trouble so often experienced may be classified into two groups—faulty construction and improper locations of the wells. It is the purpose of this paper to outline briefly the principles which should be followed in the location and construction of shallow wells and to describe the actual conditions found where such water supply development is used for municipal water supplies.

A shallow well is usually defined as one whose depth is less than 100 feet. This is not a rigid distinction, but it serves fairly well for our purposes. Wells of this class may be either open (dug) or tubular (driven or bored). Open or dug wells rarely exceed 50 feet in depth. Bored or drilled wells may be of varying depths within the limits mentioned. Both types are frequently used in developing municipal water supplies.

Open wells are of much larger diameter than the tubular well. One of the advantages of this type is that the well forms a storage reservoir for a considerable amount of water. A well 12 feet in diameter, for example, piercing the water bearing stratum to a depth of 30 feet, has a storage capacity of a little more than 25,000 gallons. When the pumps are operated at a variable rate, the storage capacity tends to increase the real capacity of the well. Furthermore in the operation of pumps there are a number of advantages in drawing the entire supply from a single large well rather than from a number of small ones. If it becomes necessary to lower the pumps the large well permits the use of more economical pumping machinery. While the yield from a well of comparatively large diameter is somewhat greater than that which may be obtained from the small bore well,

[1] Presented before the Iowa Section meeting, November 2, 1922.

[2] Associate Professor of Sanitary Engineering, State University of Iowa, Iowa City, Iowa.

it does not increase directly with the diameter. A well 10 feet in diameter will yield approximately 125 per cent more than a 6-inch well under the same conditions.

Tubular wells are generally driven into the water bearing stratum. They are of small bore and seldom exceed 12 inches. Because of the small diameter, which limits the storage volume, as well as the small area through which water flows into the well, the velocity of the inflowing water is considerably higher than that of water entering a large well which furnishes the same amount of water. This higher velocity tends to move particles of sand toward the well and causes trouble by clogging. Special strainers are used in tubular wells to prevent the entrance of sand. The cost of construction of tubular wells is less per unit of yield than for dug wells. In fact, it may be cheaper to put down several small diameter wells, connected with the same suction line, than to build a larger well. Economy in construction is the advantage which tubular wells have over open wells, while difficulty in operation constitutes the disadvantage.

LOCATION OF WELLS

In order to furnish the large quantity of water needed for a municipal water supply a shallow well must reach a large and relatively porous water bearing formation. Wells of this type are not often found piercing a rock stratum, except in limestone country where underground streams are sometimes tapped. Strata of sand and gravel having large areas furnish the most uniform and constant sources of the underground water which may be reached by shallow wells. The finer sand and clay formations are not satisfactory because of their lower porosity and resultant frictional resistance to the movement of water through them.

The water table or surface of the underground water at any place is dependent on the topography. In a country that is rough, cut up into many hills and valleys by drainage channels, the water table will be at some distance below the ground surface on the high lands and much nearer to the ground level in the lowlands. In old geological areas, where the drainage lines are relatively stable we often find extensive deposits of water bearing material in the valleys which will furnish plenty of water when tapped by shallow wells. In general, the water table has a surface which conforms with that of the ground surface but with more gentle slopes.

Shallow wells, then, should be located on lowlands if they are to furnish considerable quantities of water and at points where a good water bearing formation of considerable area may be pierced without going to great depths.

The quantity of water to be obtained, however, is not the only requisite. The well should be so located as to furnish a water of satisfactory quality. It should be removed from all possible sources of contamination. Some judgment will be needed in obtaining a satisfactory location, for not only must present conditions be considered but possible conditions which may arise as the city grows. Shallow wells should be developed out of the path of the natural drainage lines from the municipality. It is far better to locate wells of this type at some distance to one side of the main drainage axis of the city than it is to put them along this axis even though at the time of development the distance from possible sources of contamination seems to be a safe one. The writer has observed many instances where the municipality has grown toward the waterworks plant and as a result the quality of the water has become less and less safe each year until finally the wells have been abandoned.

Shallow wells should be so constructed that surface water may not get into them. The curb on open wells should be water tight to a depth of 10 or 12 feet and should extend above the ground surface so that the grading around the well will slope away in all directions. It is good practice to provide housing over large open wells. Tubular wells have the water-tight casing and should be given the same surface protection as open wells. The practice of partially digging a shallow well and then driving tubular wells in the bottom of the well has certain advantages in increasing the yield at less cost than would be incurred if the well were dug for the entire depth. The principal advantage is that the pumps may be lowered. The construction of manholes around the tops of tubular wells for the purpose of protecting the well-head from frost action should be carefully planned so that surface water will not collect in the manhole and overflow into the well. The writer recalls one instance where the well casing projected only a few inches above the bottom of the manhole. The suction pipe was smaller than the well casing so that there was an open annular space through which surface drainage could flow over the edge of the casing into the well. As the manhole did not extend above the surface of the ground surface wash entered. The importance of protecting wells from surface contamination cannot be too strongly emphasized.

With these points in mind let us consider briefly some actual instances of municipal water supplies which are obtained from shallow wells. These installations have been chosen not because they exemplify good practice, but because in each case there is a lesson for those persons dealing with shallow wells. After all we may learn more from failures than from successes.

SOME EXAMPLES OF MUNICIPAL SHALLOW WELLS

A city of 2000 population obtained its public water supply from five dug wells which were located on low ground within one block of the business district. These wells were of the dug type. One of them was located at the side of the main business street and protected by a *cracked* concrete cover, another was within 15 feet of an artificial pond, which received considerable street drainage in wet weather, the other three were in a vacant lot considerably lower than the adjacent land. In every instance it was possible for surface drainage to enter the well. Each well was connected with a sump well at the pump house to which water flowed by gravity. The quality of the water was bad and the quantity insufficient to meet the needs of the city.

This installation is an example of poor location in the first place, with lack of proper protection from surface drainage adding to the hazard. This community tolerated such a condition for many years. During the last few years the fact that the city water was not safe to drink was recognized and freely admitted by the citizens. It was used only for flushing and fire purposes. In many houses there were three sources of water supply, the public system for bath rooms, a cistern to collect rain water for laundry purposes and a private well as the source of drinking water. It is not difficult to imagine that, with three sources of water supply in the house, a mistake might easily occur. About a year ago the well system was abandoned. The present supply is obtained by filtration of a surface water.

A town of 900 population, located near the drainage line between the Missouri and Mississippi Rivers, is built around a public square. About six years ago the citizens decided to build a public water supply system. Since shallow wells had furnished plenty of water at private houses it was thought that all that was necessary to secure a satisfactory supply for the proposed public system was to dig a large well. Evidently the only consideration given to the location

was that it should be as close to the center of the town as possible so that the problem of distribution might be simplified and the expense of constructing the system be kept at a minimum. The well, pumping plant and elevated tank were built within half a block of the public square. The well is 12 feet in diameter and 40 feet deep. There is no sewerage system in the town and open pit privies are used. With several of these privies within fifty feet of the well, it is not surprising that the water was condemned by the State Board of Health.

In this particular case the surface protection of the well was fairly good, but the impossibility of obtaining a satisfactory supply in this location would have been immediately recognized by any experienced waterworks man. The town in question is still struggling with its water supply problem and, judging from its further unfortunate experience with a well 375 feet deep, which furnishes a limited quantity of a highly mineralized water, it has not yet realized the value of obtaining competent engineering advice.

The experience of a third town illustrates the fact that a shallow well which had furnished a satisfactory supply may gradually become contaminated as the distribution system is extended. This is a case where the distribution system has been extended into a residential section which is not sewered. The result is that the underground water is receiving contamination from cesspools that is increasing in volume every year.

The town in question has a population of 1400 and is divided by a river. The business and larger residential districts are located on the east side of the river, while a smaller residential area, containing about one-third of the total population, is on the west side. As is often the case the river has a broad alluvium plain which is underlain by a sand and gravel formation of considerable area and depth. This is an excellent water bearing formation in which the underground water flows toward the river. The city well, 18 feet in diameter and 24 feet deep, is located on the west bank about 75 feet from the stream. The general direction of ground water flow is southeast. There are now ten cesspools within two blocks, the nearest being about 250 feet from the well, in the territory northwest of the plant. While bacteriological pollution has not appeared, the chemical composition of the well water, as determined by examinations made during the last eight years, shows evidence of increasing pollution of the ground water feeding the well. It is probable that

the water from this source will soon become unsafe if the pollution of the ground water is allowed to continue. The use of modern plumbing in the homes, made possible by a public water supply system, bids fair to become a boomerang in this city unless provision for the removal of waste water is made.

One of the most interesting examples of shallow wells as sources of municipal water supply was found during the course of a sanitary survey by the writer a few months ago. A town of some 900 population is located on the northern slope of a broad river valley. The business district is on low ground about three-quarters of a mile from the river. The residential sections are on the slopes which rise gradually from the center of the town toward the north and east, so that the main drainage axis of the town for both surface and ground water runs south from the business district. The town waterworks plant is located on this axis and in the first block south of the commercial center.

Water is obtained from six driven wells, 6 inches in diameter, spaced approximately 3 feet apart. These wells are located in the basement of the city hall which was evidently built over the waterworks plant. The wells are cased with 6-inch galvanized iron pipe. A 3-inch suction pipe from each well is connected with the main suction pipe of the pump. The casing projects about 3 inches above the concrete floor of the basement. There is an annular opening between well casing and the suction pipe at each well-head. This is covered by a loose tin cap which possibly serves to keep out dirt but is not water-tight. The basement in which the wells, pumps and pneumatic tanks are located was drained through a tile pipe which discharged into a ditch about 100 feet back of the building. The difference in elevation between the basement floor and the outlet of this drain was about 18 inches. No check valve was provided on this drainage line.

An unusually large rainfall early last spring flooded the ditch into which the drain discharged and caused surface water to flow back through the drainage line, flooding the basement to a depth sufficient to submerge the tops of the wells Fortunately the town officials recognized the seriousness of the situation and after issuing a warning to the public that the city water was unsafe, took immediate steps to clean out the wells, disinfect the entire system and fix the drainage system so that flooding of the wells might be prevented in the future. This is an example of a shallow well development in which the pro-

tection of the wells from surface contamination would appear to the casual observer to be entirely adequate but where a careful examination of the situation would show its inadequacy.

This same development will serve to illustrate the danger of locating shallow wells on the main drainage axis of the town. Until this past year cesspools and privies have been the only means of disposing of sewage. (A sewerage system and sewage disposal plant were constructed in 1921 and put into service early in 1922.) There is heavy contamination of the underground waters within two blocks north of the well. That this contamination affects the municipal wells is shown clearly in the results of the few examinations that have been made during the last four years. In 1918, laboratory examinations of a sample of water from the municipal supply showed the following chemical composition: nitrites, nitrates, 25; and chlorine, 72 parts per million. On a sample analyzed in June, 1922, the results obtained were as follows: nitrites, 0.008; nitrates, 30; and chlorine, 98.5 parts per million. These examinations, while too few to give conclusive evidence, certainly indicate gradually increasing contamination.

During the sanitary survey samples of water were also taken from private wells in different sections of the town. The results of laboratory examinations of these samples showed the influence of the density of population in the vicinity of the wells. Water from wells located near the center of the town gave results on chemical examination almost identical with those on water from the municipal wells. The following table gives the results on well waters in different sections of the town.

WELL	CHEMICAL RESULTS IN PARTS PER MILLION		
	Nitrites	Nitrates	Chlorine
	p. p. m.	*p. p. m.*	*p. p. m.*
A	0.016	20.0	71.5
B	0.700	10.0	121.2
C	0.001	0.2	3.0
D	0.000	0.1	5.0

"A," municipal well on main drainage axis.
"B," private well on main drainage axis below "A."
"C," private well near western edge of town.
"D," private well near eastern edge of town.

It will be noted that well "B" shows results even more unsatisfactory than those obtained from well "A," while the results from wells "C" and "D" indicate that the ground water at points located some distance from the main drainage axis is of much better sanitary quality.

SUMMARY

Where suitable water bearing strata of considerable area may be reached within a depth of 100 feet shallow wells may be used. These may be either of the dug or tubular type. In locating the well care should be taken to choose a location removed from the main axis of the surface and underground drainage from the town. There is danger of underground as well as surface contamination. The former may be eliminated by proper location of the well and the latter by proper construction.

BACTERIUM COLI AND BACTERIUM AEROGENES IN SWIMMING POOLS[1]

By Max Levine[2] and C. H. Werkman[3]

The methods of bacterial examination of swimming pools are at present practically identical with those employed in water analysis. A swimming pool is not a drinking water, except in so far as the novice may utilize it as such, nor is it to be considered an enlarged bath tub. Nevertheless, from the point of view of bacterial contamination, it must be recognized that the water may serve as a vehicle of infectious diseases, exactly as drinking water does, and a swimming pool may be utilized by many not merely as a form of exercise, but also (unintentionally perhaps) as a cleansing agent. Undoubtedly some other form of bacterial analysis than is now employed would be desirable, but, for the present, the determination of the total number of bacteria and the prevalence of intestinal forms serves in a general way to give some idea, as to the likelihood of transmitting intestinal diseases, in case the water is inadvertently swallowed, and to what extent the pool has been used as a body cleanser.

In the bacterial examination of water considerable emphasis is placed upon the detection of gas-forming bacteria, particularly members of the colon group. It is now quite well recognized that all members of the colon group are not the true *Bacterium coli* of intestinal origin. At previous meetings of this section it has been repeatedly brought to your attention that there are two distinct types of such bacteria, one of which, the *Bact. coli* is characteristic of human and animal sewage, and the other, which is spoken of as *Bact. aerogenes*, is rarely encountered in such dejecta, but constitutes the predominating type in the soil and on grains. Thus, for example, among 4371 cultures from the intestinal contents of man and

[1] Presented before the Iowa Section meeting, November 2, 1922.

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various animals, only 286 (6.5 per cent) were of the *Bact. aerogenes* type, whereas the remaining 4085 (93.5 per cent) were of the *Bact. coli* type. On the other hand, among 1041 cultures obtained from the soil and from grains, there were but 144 (12.7 per cent) of the *Bact. coli* and 997 (87.3 per cent) of the *Bact. aerogenes* type. We have suggested, therefore, that, in water analysis, an attempt should be made to distinguish these two types of bacteria as they may yield valuable information regarding the source of pollution. This differentiation may be readily made, for the purpose of routine analysis, by employing the simplified eosine methylene blue agar.

It is the purpose of this paper to point out that such differentiation was found to be a valuable aid in locating the source of contamination in swimming pools.

In the examination of two swimming pools, one of which is used exclusively by men and the other by women, it was found that the gas forming organisms, when present, were usually of the *Bact. coli* type in the case of the men's pool, whereas in the women's pool the gas-formers were practically always *Bact. aerogenes*. The incidence of *Bact. coli* and *Bact. aerogenes* in the men's and women's swimming pools is given in the following table.

Incidence of gas formers in pools in 10 cc. samples

POOL	NUMBER OF TUBES OBSERVED	TUBES SHOWING GAS	GAS FORMING ORGANISMS PRESENT			
			Bact. coli alone	*Bact. aerogenes* alone	*Bact. coli* and aerogenes	Other gas formers
Men's.....	318	31	19 (61.3)	3 (9.7)	8 (25.8)	1 (3.2)
Women's.....	234	92	0	74 (80.4)	15 (16.3)	3 (3.3)

Figures in parentheses indicate per cent of tubes showing gas.

Among 318 samples of 10 cc. examined from the men's pool, 31 (9.8 per cent) contained gas formers, as compared with 92 (39.3 per cent) of the 234 samples observed from the women's pool. Of the 31 tubes showing gas in the men's pool, 19 (61.3 per cent) contained *Bact. coli* alone, only 3 (9.7 per cent) *Bact. aerogenes* alone, and 8 (25.8 per cent) a mixture of the two bacterial types. On the other hand, among the 92 gas forming tubes from the women's pool, *Bact. aerogenes* was the sole colon form present in 74 (80.4 per

cent), and *Bact. aerogenes* together with *Bact. coli* was found in 15 (16.3 per cent) of the tested samples. In no instance was *Bact. coli* present alone in a positive fermentation tube.

Considering the foregoing statement regarding the distribution of the *Bact. coli* and *Bact. aerogenes* in nature, we expected to find the true *Bact. coli* forms predominating in both pools. The results obtained were, therefore, quite anomalous. It appeared inconceivable that the intestinal flora could be appreciably different with the sexes, and, as the two pools were receiving the same amount of chemical treatment (0.5 p.p.m. $CuSO_4$ twice a week and 1 p.p.m. of bleaching powder once a week), it was thought that possibly the differences might be due to the fact that the men's pool was equipped with a filter and the women's pool was not. It was found, however, that after the installation of a filter in the women's pool the results remained the same. *Bact. aerogenes* was the prevailing and almost exclusive gas former and gas producing bacteria were much more prevalent in this pool than in the men's.

The two pools differ in one other respect, namely, location. The men's pool is situated on the ground floor. It is lighted by windows well up above ground (10 to 12 feet), which are rarely opened, and there is a balcony provided for visitors. The approach to the pool is so arranged that it is practically impossible to track in any appreciable quantities of mud or street dirt.

The women's pool is situated in a basement and is lighted artificially and by windows which are below the level of the ground and usually open to assist in ventilation. There is no provision for visitors nor do the arrangements for approach to the pool prevent tracking in of street dirt. Visitors, when present, enter with street shoes and soil the runways around the pool, facilitating seeding with soil organisms, and considerable dust must inevitably find its way into the pool through the windows. This circumstance, namely that one pool is admirably protected against dust and street washings, whereas the other is subject to contamination from these sources, probably explains the bacterial findings.*

The results obtained serve to confirm our previous contentions that (1) *Bact. coli* and *Bact. aerogenes* are characteristically of different origin and (2) differentiation of these forms in water analysis is desirable as an aid to the determination of the source of contamination.

* The inauguration of changes in the method of operating the women's swimming pool, so as to prevent the tracking in of street washings and mud, has resulted in almost complete elimination of *Bacterium aerogenes*.

THE RELATIVE MERITS OF LIME-SODA AND ZEOLITE WATER SOFTENING[1]

By A. S. Behrman[2]

Water softening is fast coming into such general practice that every waterworks man is being brought more and more in contact with the subject. Whether in an operating or consulting capacity, he frequently must make decisions or recommendations as to the most advantageous method of treatment and the most suitable equipment.

The purpose of this brief paper, written by a member of an organization which manufactures both lime-soda and zeolite water softeners, is to point out that neither process is to be recommended indiscriminately. Each has its advantages and each its limitations. Each has, therefore, its particular fields of usefulness, although, in a few cases, the choice is a debatable question.

The principal reason for the particular applicability of either method lies in the nature and chemistry of the processes themselves. In the lime-soda process enough lime and soda are added to the raw water to remove the calcium as calcium carbonate, and the magnesium as magnesium hydrate. In the zeolite, or base exchange process, the calcium and magnesium in the various compounds in the raw water are replaced by sodium from the zeolite, so that the softened water contains the slightly greater equivalent weights of the sodium compounds. When the zeolite has given up all of its replaceable sodium, the supply is renewed by regenerating the zeolite with a solution of common salt.

As far as hardness is concerned, the lime-soda process, as ordinarily practiced in the cold, yields a water with a residual hardness of 3 to 5 grains per gallon of calcium carbonate equivalent. The same process, carried on at or near the boiling temperature, may be made to deliver a water with a hardness of 1 to 3 grains per gallon. With the zeolite process, water may be softened to "zero hardness."

[1] Presented before the Philadelphia Convention, May 18, 1922.

[2] Chief Chemist, International Filter Company, Chicago, Ill.

It is only fair to state, however, that this "zero hardness," in commercial practice, has been variously and arbitrarily fixed to include even as high as 1.4 grains per gallon; but a properly operated zeolite softener will deliver a water that is actually practically free from calcium and magnesium compounds over the greater portion of its normal operating period.

From the standpoint of securing a water of absolutely minimum hardness, therefore, we must place zeolite softening ahead of lime-soda softening, particularly cold lime-soda softening. We must credit the lime-soda process, however, not only with softening, but, in doing so, with actual reducing the amount of dissolved solids by removing bodily the bicarbonates of lime and magnesia, with the removal of iron and free carbon dioxide, and with the reduction of organic matter, silica and alumina. Zeolite softening does not reduce organic matter, silica or alumina, nor does it remove carbon dioxide or iron. In fact, if the raw water contains an appreciable quantity of iron, the water must be pre-treated for iron-removal before entering the zeolite softener. With the zeolite, if the water is turbid, it must be filtered before passing to the zeolite, in order to prevent coating the active material. With the lime-soda process no pre-filtration is necessary, as sand filtration after reaction and sedimentation is provided in all modern equipment.

So much for the effect of the two processes on the composition of the water being treated. What other factors are to be considered?

There are several, such as the cost factor—the expense of the original installation, of treatment, and of maintenance; the labor and attention factor—how much work, physical or mental, is required to keep the apparatus functioning as it should, and the purely engineering considerations—size of the units, pressures, pumps, and the like. Let us compare the two processes in these respects.

The difference in first cost between a lime-soda and zeolite softening plant often depends on the basic fact that the size and cost of a lime-soda softener are fixed for a given hourly capacity of the plant, while the size and cost of a zeolite plant vary with the hardness of the water being treated. It requires four times the weight of zeolite to soften a thousand gallons of a 20 grain water as it would a thousand gallons of a 5 grain water, and the size and cost of the zeolite softener would increase in somewhat the same ratio. With a lime-soda softener, a variation in the hardness of the raw water means simply varying the amount of lime and soda fed, without any change in the apparatus itself.

The cost of water treatment with the two processes depends largely on the nature of the impurities. If the hardness is bicarbonate or "temporary" hardness, lime only is required in the lime-soda process; and this treatment is, therefore, much cheaper or only about one-third to one-fourth the cost of the salt in the zeolite treatment. To remove permanent hardness, the costs of the lime and soda ash in the lime-soda process and of the salt in the zeolite process are very nearly equal.

Which type of softening requires more attention? There is not a great deal of difference, as far as actual labor is involved. In industrial installations, any slight difference in attention required is rightly subordinated to the results sought from the softening.

With respect to engineering and plant operating considerations it will be sufficient merely to suggest one or two general lines of thought, as these factors naturally vary in different cases. Practically all zeolite softeners are operated under pressure, so that the original head of water to the system is maintained, less the loss of head through the zeolite. In this way re-pumping the softened water is generally avoided, though this is not always the case. In the lime-soda system, any large initial pressure is lost, as this type of softener works under a gravity head. The effective pressure of the softened water is as a rule equivalent to the elevation of the reaction and settling tanks, minus the loss of head through any filter that is provided. We must credit the lime-soda process, however, with giving continuous twenty-four hour service, while the zeolite service is intermittent, due to the necessity for regeneration. The zeolite softener, has the advantage of smaller size and it may be built with much smaller capacities than are practical with the lime-soda softener.

These, then, are the principal criteria which should govern the selection of the type of water softening for any particular industry. With these considerations in mind, we may review a few of the more important classes of industries, and see which type of softening appears most logical.

TEXTILE AND DYEING INDUSTRIES

In the textile and dyeing industries, for example, the first requirement is absolutely minimum hardness of the water used. Another requirement frequently is freedom from hydrate or caustic alkalinity

and sometimes even from monocarbonate alkalinity. The zeolite softener, therefore, properly dominates this field. Lime-soda softening is logical as a pre-treatment in the case of an iron-bearing water, or a water that has such high temporary hardness that the expense of installing a zeolite softener to treat the water directly is prohibitive. Such cases are relatively rare, since the seat of the textile industry is mainly on the Atlantic seaboard, where the waters are comparatively free from iron and low in temporary hardness.

LAUNDRIES

To zeolite softening, also, properly belongs a large share of water softening for laundries. The exceptions are, as before, in the case of waters containing appreciable quantities of iron, or large amounts of temporary hardness or free carbon dioxide. In these cases, it is desirable to use lime-soda softening, followed, where indicated, by a zeolite.

DOMESTIC INSTALLATIONS

Domestic water-softening installations are usually also logically of the zeolite type. They occupy little space and operate under pressure. The salt for regeneration may be handled by the housewife more easily than lime and soda. For this type of work the utmost simplicity is desirable, even at a possible sacrifice of economy and efficiency.

RAW WATER ICE

If we turn to the softening of water for the manufacture of raw water ice, we find requirements just the reverse of those in the textile industries. There the prime requisite was minimum hardness. In raw water ice the hardness is usually more or less incidental. The ideal sought is a water as low as possible in dissolved salts, organic matter, silica, alumina and iron. Bicarbonates, even of soda, are objectionable. For raw water ice, lime-soda softening is the logical treatment. It removes iron, reduces organic matter, alumina and silica, and reduces the amount of dissolved solids by removing bodily the bicarbonates of lime and magnesia. Zeolite softening, as has been pointed out, has no effect on the iron, organic matter, alumina and silica in the raw water, and replaces the bicarbonates of lime and magnesia with the equivalent greater quantity of bicarbonate of soda. In many cases, if a water high in calcium

or magnesium sulphate is softened by the zeolite process, the resulting sodium sulphate would be more objectionable for raw water ice than calcium sulphate. In the lime-soda process, simply the omission of the soda ash will secure the selective softening action desired.

BOILER FEED

In softening water for boiler feed purposes, the ideal sought is a water that is non-scale forming, non-foaming and non-corrosive.

Either lime-soda or zeolite softening, properly carried out, will yield a water that will not form scale. The lime-soda cold process softened water will form a small amount of soft sludge that is readily blown down. The water treated in the most modern type of hot process lime-soda softening equipment frequently satisfies the arbitrary definition of "zero hardness." Whether it does or not, it forms only a small quantity of sediment that is readily blown down. Zeolite-softened water will form, of course, a very small amount of sediment, which may be materially increased in waters high in silica or alumina.

Foaming and priming result both from concentration of dissolved salts and from suspended matter. The logical water treatment from this viewpoint, therefore, is the one which will leave in the treated water the least possible amount of soluble substances and which will yield on concentration a minimum of suspended matter. With waters of low initial hardness, either type of softening will frequently be satisfactory in this respect. With waters high in temporary hardness, however, there is only one logical choice. If a water high in bicarbonates of lime and magnesia is softened by the zeolite process, the treated water will contain so much bicarbonate of soda that foaming will very likely result, unless the boilers are blown down excessively. Even waters fairly low in bicarbonate hardness—8 to 10 grains per gallon—will require considerably more blowing down with the zeolite softened water than with the raw water. Occasionally the effort is made to end foaming by mixing some raw water with the treated water. But this is obviously poor practice, for this combined feed water is not free from scale-forming substances. Moreover, the reaction of the raw and treated water in the boiler causes the formation of a considerable amount of sediment or sludge, which in itself tends to cause foaming. For waters of this type, lime-soda softening is the proper treatment, and this is being more and more generally conceded.

What is the cause of boiler corrosion? There have been and will continue to be many answers to this query. I do not refer, of course, to such obvious causes as acid mine waters or strong galvanic action from stray currents or from couples. While I am not one of these who hold the H-ion concentration responsible for every phenomenon in the universe, I believe that it is reasonable to connect it with boiler corrosion. We know that there is a relation between H-ion concentration, free carbon dioxide, and bicarbonates in a water. Whether or not it is the free or halfbound carbon dioxide or the acid hydrogen which is most concerned in corrosion, we do know that, if we remove the free carbon dioxide and the bicarbonates with lime, and impart to the water a hydrate alkalinity and thus greatly reduce the H-ion concentration, there is given to the water a definitely protective influence. Zeolite softening does not remove free carbon dioxide or bicarbonates nor does it impart to the water a protective hydrate alkalinity. When the hot process lime-soda treatment is used, there is the further advantage that the water is de-aerated, ridding the water of oxygen, which is known to be connected with corrosion. Lime-soda softening is obviously logical for treating acid mine waters, whereas zeolite softening is out of the question in such cases.

The softening of water for boiler feed purposes, therefore, has the following characteristics. If the raw water has low bicarbonate alkalinity, and little free carbon dioxide, the lime-soda process may certainly be used, and the zeolite process may or may not be used, depending largely on local conditions. If the water is high or moderately high in bicarbonate hardness, or in free carbon dioxide, or if it contains any free acids, lime-soda softening is the logical treatment.

MUNICIPAL SOFTENING

As a general rule, municipal softening is most advantageously carried out by the lime-soda process. Most large communities are turning for their supply to surface waters. In most cases this involves filtration, following coagulation and sedimentation. It is apparent that, in these plants, there is little extra equipment required to permit lime-soda softening as well as filtration. While the question of after-deposits has not been absolutely settled, progress is being made in this direction, as is shown by the developments in several of the largest municipal softening plants in the country.

CONCLUSION

I have tried to outline briefly for you a rational basis for the selection of the proper type of water softening. As a paper of this kind is not intended to cover completely either general principles or specific instances, I shall be satisfied if I have impressed upon you that both lime-soda and zeolite softening have their respective advantages and limitations and that the selection of either type should be based upon fundamental considerations of these factors.

WATER-PURIFICATION PLANT OPERATION AND ANALYTICAL CONTROL IN ILLINOIS[1]

By M. W. Cowles[2]

Surface streams or reservoirs as sources of public water supplies have become of paramount importance in certain portions of the State where centers of population have developed and adequate supplies cannot be obtained from underground sources. Their objectionable turbidity and physical appearance, the discharge of sewage into the streams, and the presence of germs of intestinal diseases, have been responsible for the construction of water-purification plants, not only in Illinois but throughout the world. Although conditions here are not unusual, certain data on these plants may be of interest. These data are based upon inspections made by the staff of the Division of Engineering and Sanitation of the State Department of Public Health since the establishment of the division at the end of 1915. Because of the limited size of staff and changes in personnel source of the material is not as recent as desirable, but most of it is fairly complete and substantially accurate.

The first plant in the State was built in 1885 in East St. Louis, followed by Streator in 1889 and Quincy in 1891. Since that time, the original plants have been largely replaced. At the present time there are in Illinois 39 supplies subjected to fairly complete purification; 2 that are softened, 2 where iron is removed, 14 which are more or less continually sterilized by the use of liquid chlorine or hypochlorite, without coagulation or filtration, and 4 where sterilization is used only under emergency conditions.

The population supplied by the 39 water-purification plants, on the basis of figures given by the 1920 census, amounted to 589,385, by the 13 sterilization plants, 3,074,000 (including Chicago), and by the iron-removal and softening plants 53,515, making a total population of 3,697,231 supplied by artificially treated water.

[1] Read in abstract at annual meeting of Illinois Section, Champaign, March 29–30, 1922.

[2] Formerly Senior Assistant Engineer and Analyst, State Health Department, Springfield, Ill. Now with C. W. Marsh, New York, N. Y.

TABLE 1.

Supplies treated in filtration plants

TOWN	POPULATION 1920	TREATMENT	SANITARY QUALITY
		Storage reservoirs	
Anna State Hospital	2,013	S—RF—C	Good. Safe if properly chlorinated
Carlinville	5,212	S—RF—C	Doubtful. Inadequate purification
Eldorado	5,004	PF—C	Doubtful. Inadequate purification
Harrisburg	7,125	S—RF—C	Good
Herrin	10,986	S—RF—C	Good. Purification plant somewhat overloaded*
Macomb	6,714	S—RF—H	Good
Marion	9,582	P—S—RF—C	Doubtful. Safe if properly chlorinated
Mt. Vernon	9,815	P—S—RF—H	Good. Plant overloaded
Pana	6,122	S—RF—C	Doubtful. Safe if surface supply is given adequate purification
Salem	3,457	S—RF—C	Good
Sparta	3,340	S—RF—H	Good
	69,370		
		Impounding reservoirs	
Charleston	6,615	S—RF—C	Doubtful. Safe if purification plant is properly operated
Danville	33,750	Ae—S—RF—C	Good
Decatur	43,818	S—RF—C	Good
Effingham	4,024	S—RF—C	Good
Hamilton	1,698	S—RF—C	Good
Jacksonville	15,713	Ae—S—RF—C	Good. Plant overloaded†
Kankakee	16,721	S—RF—C	Good
Pontiac	6,664	S—RF—H	Good
Streator	14,779	S—RF—C	Good
	143,782		

TABLE 1.—*Continued*

TOWN	POPULATION 1920	TREATMENT	SANITARY QUALITY
		Streams	
Alton	24,682	S—RF—C	Doubtful. Purification plant overloaded. Safe when chlorinated
Breese‡	2,399	S	Bad. Inadequate purification
Dallas City	1,288	S—RF—C	Good. Safe if plant is properly operated
East St. Louis	130,000	P—S—RF—C	Good
Elgin§	27,431	S—PF—C—C	Doubtful. Safe if river water is properly chlorinated
Lawrenceville	7,309	S—RF—C	Good
Moline	30,734	S—RF—C	Doubtful. Plant overloaded. Bypass and inadequate clearwater storage
Mt. Carmel	7,456	S—RF—C	Doubtful. Clear-water well not properly protected
Murphysboro	10,703	S—RF—H	Good
Quincy	37,000	S—RF—C	Good
Rock Island	38,000	S—RF—C	Good. Point of chlorination should be changed
Rock Island Arsenal		S—RF—C	
Warsaw	2,031	S—RF—H	Doubtful. Inadequate purification
	334,236		
		Lake Michigan	
Evanston	37,234	S—RF—H	Good
Fort Sheridan		PF—H	Good
Great Lakes Naval Training Station		S—RF—C	Good

TABLE 1.—*Continued*

TOWN	POPULATION 1920	TREATMENT	SANITARY QUALITY
Lake Michigon—Continued			
Kenilworth	1,400	S—PF—H	Good. Chlorinated only with increase in turbidity. Should always be chlorinated
Lake Forest	3,363	S—PF—H	Good
	41,997		
Grand total	589,385		

Ae, aeration.
P, sedimentation preliminary to addition of coagulant.
S, coagulation and sedimentation.
RF, rapid sand filtration, gravity type.
PF, pressure filter.
H, calcium hypochlorite.
C, liquid chlorine.
* Additional capacity being provided.
† Additional capacity to be provided.
§ River water at Elgin chlorinated twice, is used to supplement a supply obtained from wells.
‡ At Breese, coagulation without filtration is available.

The water-purification plants have been classified in Table 1, according to source, population served, treatment and quality of effluent. Figures for the average daily consumption of the various plants are given in table 4. The classification of sources, storage reservoir, impounding reservoir, stream and lake, has been chosen so that the load placed upon the purification plants listed may be considered of about the same average order of magnitude and subject to about the same variations. A storage reservoir is considered as one located on a drainage area, the dry-weather run-off from which is negligible and the water impounded represents the greater portion of the run-off, deducting, of course, the various losses. Such a water would be subject to natural purification agencies to a considerable degree and would not show great variation in quality or physical characteristics, except occasionally. An impounding reservoir may be considered as located on a flowing stream which will impound only a certain portion of the flow during wet weather and possibly

the entire flow during dry weather. Such a water would be subject to large variations in quality and physical condition unless large storage capacity were available. The amount of such variation would be more than that shown by a storage reservoir, but less than that shown by water obtained directly from streams. Supplies obtained from Lake Michigan resemble those obtained from storage reservoirs, but conditions are somewhat different and, therefore, they are classified separately.

Table 2 show the supplies where sterilization is used regularly or under emergency conditions without other treatment. Table 3 lists surface water supplies more or less used for drinking purposes without purification.

PURIFICATION PROCESSES

The various processes by which water is purified, excluding softening and iron removal, take place in four stages (1) preliminary treatment, including pre-sedimentation, aeration, etc.: (2) coagulation, followed by sedimentation: (3) filtration: and (4) sterilization. For convenience, the first two groups will be discussed together as treatment preliminary to filtration.

Treatment preliminary to filtration. At Danville, a splash aerator, consisting of vertical pipes discharging onto circular perforated shields or "umbrellas" is used. The arrangement at Murphysboro is somewhat similar, but consists of a vertical pipe discharging into the air about 3 or 4 feet above the level of the water in the chamber into which it falls. At Jacksonville, spray nozzles operated by gravity flow from the reservoir are used.

The total sedimentation and coagulation period (table 4) used varies for water from storage or impounding reservoirs from 2.1 hours at Pontiac to 9.6 hours at Streator and for water from streams from 2.2 hours at Moline to 18.0 hours at Rock Island.

At East St. Louis, assuming a normal daily raw-water pumpage of 20 million gallons, the pre-sedimentation period alone amounts to about $5\frac{3}{4}$ hours and the coagulation period about $9\frac{1}{2}$ hours. This period is probably sufficient during times of low turbidity and relatively low bacterial content, but during times of high turbidity, or when the water is rather highly polluted, this period is insufficient and causes overloading of the filters and poor quality of filtered water, prior to chlorination.

TABLE 2

TOWN	OWNERSHIP	SOURCE	POPULATION 1920	CONSUMPTION M.G.D.	STERILIZING AGENT	CONTINUITY OF OPERATION	DATE INSTALLED
Supplies subjected to sterilization without filtration							
Benton	P	SR	7,201	0.2	C	Continuous	1921
Carbondale	P	RW	6,267	0.2	C	Continuous	1918
Centralia (b)	P	SR	13,739	1.5	C	Continuous	1919
Chicago (a)	M	LM	2,792,000		C†	Continuous	
Christopher	M	SR	3,830	0.5	C	Intermittent	1919
Duquoin	P	Mine	7,285	0.3	C	Continuous	1922
Highland Park (c)	M	LM	8,272	1.6	C	Continuous	1915
Nauvoo	M	MR	972		C	Continuous	1921
North Chicago	M	LM-RW	5,839	1.25*	C	Intermittent	1914
Paris	M	SR	7,985		C	Continuous	1921
Tuscola	P	RW	2,564	0.09	C	Intermittent	1920
Watertown Hospital	State	RW	1,617	0.15*	C	Intermittent	1920
Waukegan	M	LM	19,226	4.8	H	Continuous	1915
Winnetka	M	LM	6,694	0.7	C	Continuous	1911
Total			2,883,000				
Supplies sterilized only in emergency							
Aurora	M	RW	36,397	3.5*	C	Emergency	1914
Freeport	P	DW-RW	19,669	2.0	C	Emergency	1922
Peoria (d)	P	DW	76,121	9.0	C	Emergency	1919
Springfield	M	DW	78,183	6.5	C	Emergency	1917
Total			191,360				

SR, storage reservoir.
IR, impounding reservoir on stream.
MR, Mississippi River.
LM, Lake Michigan.
DW, Drift wells.
RW, rock wells.
M, municipal.
P, private.

(a) Chicago also supplies water wholly or in part to 13 communities in Cook County.

(b) Centralia also supplies Central City.

(c) Highland Park also supplies Highwood.

(d) Peoria also supplies Bartonville, Averyville, and Peoria Heights.

* North Chicago—Lake water only, chlorinated.
Watertown—About 60 per cent of supply treated.
Aurora—Supply from main station (90 per cent) treated.

† More than one chlorinator available.

TABLE 3

*Supplies from untreated surface sources**

TOWN	OWNERSHIP	SOURCE	POPULATION 1920	CLASS
Avon	P	Storage reservoir	877	A
Carlyle	M	Kaskaskia River	2,027	C
Carmi	M	Little Wabash River	2,667	B
Chester	P	Mississippi River	2,904	C
Fairfield	M	Storage reservoir	2,754	A
Freeburg	M	Storage reservoir	1,594	A
Grayville	M	Wabash River	1,749	C
Greenup	M	Embarrass River	1,230	C
Hillsboro	M	Storage reservoir	5,074	A
Johnston City	P	Impounding reservoir-lake	7,137	B
Kincaid	M	Storage reservoir	1,453	A
Litchfield	P	Impounding reservoir	6,215	B
London Mills	P & M	Spoon River	546	B
Louisville	M	Little Wabash River	797	B
Mattoon	M	Storage reservoir	13,552	B†
McLeansboro	M	Storage reservoir	1,927	A
Mt. Olive	M	Storage reservoir	3,503	B
New Athens	M	Kaskaskia River	1,406	C
Newton	M	Embarrass River	2,083	B
Olney	M	Fox River	4,491	B
Pinckneyville	M	Impounding reservoir	2,649	A
St. Elmo	P	Storage reservoir	1,337	A
Staunton	M	Storage reservoir	6,027	A
Toledo	M	Storage reservoir	787	A
Vandalia	M	Kaskaskia River	3,316	C
Waterloo	M	Impounding reservoir	1,930	B
Whitehall	M	Storage reservoir	2,954	A
Zeigler	M	Big Muddy River	2,338	C
Total			71,772	

A, Storage reservoir receiving drainage from farms, etc.

B, Stream receiving drainage from farms and unsewered communities.

C, Stream receiving sewage untreated or partially treated, from communities upstream.

* The department considers an unpurified surface water as unsafe for drinking purposes. None of these supplies are obtained from patrolled drainage areas, but even if such were the case, the same opinion would hold.

† Used for industrial purposes only and not included in the total given.

TABLE 4

Coagulation and sedimentation data at water-purification plants

TOWN	CONSUMPTION AV. M.G.D.	SOURCE	PREVIOUS TREATMENT	CHEMICALS			MIXING PERIOD	COAGULATION AND SEDIMENTATION PERIOD	NATURAL ALKALINITY*	
					Maximum	Minimum			Maximum	Minimum
							minutes	*hours*		
Alton	3.20	S		LI				3.5–4	175	120
Anna State Hospital	0.27	SR		A				4	200	105
Breese (d)	0.15	S		LA				35		
Cairo		S		LA					140	60
Carlinville	0.40	SR		A				3.3	195	50
Charleston	0.80	IR		A			13	2.8	215	
Dallas City	0.01	S		A				2.0	93	95
Danville (e)	6.00	IR	Ae	L	8.1	0.14	10–12	6–7	240	140
				A	11.0	0.10				
Decatur	5.00	IR		A	7.0		25	3.7	315	105
East St. Louis	22.00	S	P 5.7	L-A	3.6	0.25	1–2	8.75	235	120
Effingham	0.75	IR		L-A	9.5	0.11		3.0	260	50
Eldorado	0.10	SR		A					35	35
Elgin	2.70	S		A				0.0	325	
Evanston	12.00	L		A			20	1.7	140	140
Fort Sheridan		L		A						
Great Lakes Naval Training Station	2.00	L		A				12.0		
Hamilton	0.07	IR		A			1–2	3.0	190	130
Harrisburg	0.21	SR		L-A	2.0	0.10	30	2.9	100	8
Herrin	0.80	SR		L-A			36	2.5	55	10
Jacksonville	1.80	IR	Ae	A			4	2.2	135	
Kankakee	2.20	IR		A				2.5	270	90
Kenilworth	0.20	L		A			1–2(c)	1.0		
Lake Forest	1.00	L		A				2.4		
Lawrenceville	0.30	S		L-A	6.6	0.1	15	3.2	150	40
Macomb	0.30	SR		A				4.2		
Marion	0.33	SR	P(a)	A				0.8	150	25
Moline	2.40	S		A				2.2	200	70
Mt. Carmel	0.72	S		A	9.0		5	2.5	250	30
Mt. Vernon	0.70	SR-S	P(a)	A			12	4.0	85	31
Murphysboro	1.25	S	Ae	NA			15	7.5	386	6

*Alkalinity to methyl orange.

TABLE 4—*Continued*

TOWN	CONSUMPTION AV. M.G.D.	SOURCE	PREVIOUS TREATMENT	CHEMICALS			MIXING PERIOD	COAGULATION AND SEDIMENTATION PERIOD	NATURAL ALKALINITY*	
					Maximum	Minimum			Maximum	Minimum
							minutes	*hours*		
Pana	0.50	SR		A			35	4.0	60	20
Pontiac	0.80	IR		A				2.1	100	
Quincy (e)	1.80	S		LA			1–2	4.6	205	125
Rock Island (e)	3.50	S		A			1–2	18.0	185	70
Rock Island Ars. .		S		A						
Salem	0.25	SR		LA			15	3.9	75	20
Sparta	0.10	SR		A				3.0		
Streator	1.75	IR		L-A	4.0	0.3	1–2	9.6(b)	315	80
Warsaw	0.05	S		A				2.3	190	140

SR, storage reservoir.
IR, impounding reservoir
S, stream
L, Lake Michigan
Ae, aeration
P, sedimentation prior to addition of coagulum
LA or LI, lime and alum or iron
M, soda ash
(a) Sedimentation in surface pond near waterworks.
(b) Lime and alum added regularly to suction l. s. pumps followed by a period of 7.0 hours and alum again added to second basin followed by period of 2.6 hours.
(c) Alum added to suction pumps.
(d) Coagulation in 4 basins, without filtration.
(e) Raw waters sometimes have considerable color, 40, or more.

At Rock Island and Streator, the basins are arranged so that sedimentation prior to coagulation might readily be permitted and more economical and possibly somewhat better operation of the plant as a whole could be obtained in this manner. At other plants supplied either from streams or small reservoirs where the variation in suspended material is considerable, better results could also be obtained if a pre-sedimentation period were provided prior to and in addition to the sedimentation after coagulation.

In some of the smaller plants, the capacity of each part of the purification plant greatly exceeds the demand of domestic consump-

tion and the plant, therefore, operates only a few hours each day. Where the coagulant is added without pre-sedimentation, as is usually the case, the alum floc will settle out and that reaching the filters will be insufficient to form a proper mat on the top of the sand. Provision for a second dose of alum might be of value. Such a condition is unsatisfactory. More attention should be paid to this feature of design in providing a more flexible plant.

The plants at Rock Island and Streator are arranged so that, with a few minor changes, the point of addition of the coagulant may be changed in accordance with the quality of the raw water, thereby giving the plant more flexibility to meet adverse conditions.

In table 4 are shown the coagulating chemicals used at the various plants. With the exception of Alton and Herrin (temporarily), all use alum and a number also lime or soda ash when required. Recent analyses of some of the raw waters from plants which now do not use lime or soda ash have shown that the natural alkalinity of the water as measured by methyl orange, may fall below 40, indicating the necessity of the addition of some alkaline material, especially during the winter months when the lower temperature of the water tends to slow down the rate of chemical reaction.

Inspections made of 23 of the purification plants within the past 18 months have shown that the facilities for adding coagulants are, in many plants, crude and may not be depended upon to provide an even dose or one which may be proportioned in accordance with raw-water flow at any particular time. Hand operation of a gate valve is often depended upon to secure variation in coagulant. Decatur, East St. Louis, Quincy, Hamilton, Herrin, Marion, Rock Island, Salem, Sparta, Streator and Dallas City have devices which are capable of satisfactory control. A few of the plants, especially the larger ones, have automatic devices for varying the amount of coagulant added in proportion to the raw water pumped.

At Rock Island, an attempt has been made to use a solution of 4.8 per cent strength which has resulted in corrosion not only in the solution controlling devices, but also to a greater extent in the pipe line leading a distance of 350 feet to the point of application of the coagulant. Lead lined, galvanized, and fiber pipe were unsatisfactory and lead is now being substituted. A 2 or 3 per cent solution would be less corrosive and probably would produce as satisfactory results.

When the addition of alkaline material is necessary to secure proper precipitation of the coagulant, the alkaline material and the coagulant are sometimes added to the water either through the same or separate pipes at the same point. It is believed that this method is undesirable for either lime or soda ash. In the case of lime, it may be somewhat more objectionable than in the case of soda ash, on account of the lower solubility of hydrated lime in cold water and the tendency for small particles of suspended lime which are not in solution to be carried along mechanically and, therefore, of little influence for the purpose for which it was added. In either case, better and more satisfactory results could be expected, if the alkaline material is added and thoroughly mixed with the raw water a short time before the coagulant is added. If added a considerable time before the coagulant, some softening action may occur, requiring the use of amounts of lime or soda ash greater than that required by the coagulant alone, but with better results. If it is not considered desirable to add the chemical in the suction of low-service pumps, a satisfactory mixture of the raw water with the alkaline material may be obtained by passing the raw water through a Venturi section or reduced section in the raw-water conduit. Laboratory experiments by Dr. F. A. Hale at the Mount Prospect Laboratory in Brooklyn have indicated that complete dispersion of chemical in the water to be treated may be obtained in this manner. Ellms has also proposed the "hydraulic jump" for securing a proper mixture.

A number of the Illinois plants are designed without adequate facilities for securing thorough mixture of raw water with coagulant solution. Of the 23 plants inspected, 20 have some provision for mixing chambers, the length of time varying from 1 to 2 minutes to a maximum of 36 minutes, based on the average consumption. Danville, Jacksonville, and Salem, recently completed plants, have periods of 10 to 12, 4, and 16 minutes, respectively. At Jacksonville, the plant is carrying an overload of about 50 per cent, and mixing and coagulation basins and an additional filter will shortly be provided.

Recent experiments made at Sacramento, California[3] have shown that most satisfactory results in coagulation may be obtained by the use of a mixing chamber having a velocity of 2 feet per second. Such a mixing chamber must be baffled in such a way that the velocity at

[3] Engineering News-Record, vol. 86, no. 22, p. 924, W. F. Langelier.

all points is as nearly uniform as possible and at least it does not drop below the velocity at which sedimentation will occur. Mechanical stirring devices also produced good results and had a decided advantage over the closely baffled tank in that the capacity was more flexible. After the coagulant is added and the water has passed through the mixing chambers it is suggested by Mr. Langelier that more efficient coagulation may be obtained by gradually decreasing the velocity, increasing the cross section of the coagulation basin, and further that the velocity in this basin should vary between a higher limit of 0.15 and a lower limit of 0.02 foot per second.

Many articles with reference to the chemical processes involved in coagulation have recently appeared in the literature. Ellms in a recent paper[4] before the American Water Works Association at Cleveland, emphasized the necessity of proper reaction periods for the chemical changes to occur, and urged that more attention be given to the factors which are known to affect the speed of a chemical reaction, temperature, contact of reacting substances, etc.

Proportioning the amount of coagulant to the turbidity of the raw water is not given proper attention. The arrangement used at Decatur (similar devices may be used at other plants in the State) has much to recommend it. The approximate amount required for different turbidities, as determined from plant records, has been plotted. Minor variations are made by observing the size of the floc as it passes to the filters by means of an electric light bulb hanging just above the surface of the water.

"Rule of thumb" methods are still necessary, but do not preclude the use of available tests to secure additional information. It is hoped that before long, colloidal chemistry may give us a better measuring device.

It is also interesting to note that at one plant, Breese, coagulation and sedimentation for a period of about 35 hours constitutes the entire treatment given a surface supply from Shoal Creek. The treatment is inadequate and filters should be installed. Lime and iron was used at one time, but has apparently been replaced by lime and alum.

Filtration. In the 36 plants, for which data are available (table 5), there are 174 filter units including 116 concrete filters, 12 vertical steel tubs, 18 vertical wooden tubs, 6 vertical steel tanks, and

[4] Eng. & Contract., January 11, 1922, p. 55.

TABLE 5

Data on filters at the various purification plants

TOWN	OWNERSHIP	ESTIMATED POPULATION SUPPLIED (a) 1920	SOURCE			FILTERS					RATE CONTROLLERS		LOSS-OF-HEAD GAGES		SAND				WASHING	
			SR	IR	S or L	Previous treatment	Type	Material	Number	Total capacity	Available	Set	Available	Set	Depth	Eff. size	Unif. coeff.	Condition	Air	Water In. vert. rise per minute
															inches				*minutes*	*minutes*
Alton	P	24.682			S	C	G	C	8	4.7	Y	Y	Y	N	24	1.45	1.23	Growth, heavy coating	5–6	4–12
																(b)0.87	1.14			22
Anna State Hospital	State	2.013	SR			C	G	C	3	1.0	N(c)		Y	N(d)	30	0.55	1.13	Brown coating		18
Breese	M	2.399			S	C														
Cairo	P	15.203			S		G	W	6	3.0	Y	N	Y	N	12–14				6	11
Carlinville	P	5.212	SR			C	G	W	1	0.44	N		N		12					7.5
Champaign	P	2.117				A	G	C	4	2.0	N		Y	Y	25	0.30	5.00		4	12
Charleston	M	6.615		IR	W	MC	G	C	2	1.0	N		Y	N	30	0.83	1.3			4.8
Dallas City	M	1.288			S		G	C	2	0.6	Y(e)	Y	Y	Y	24	0.46	1.24		20	4
Danville	P	33.750		IR		AMS	G	C	9	7.0	Y		Y	N	30	0.62	1.50	Heavy coating		5.6
Decatur	M	43.818		IR		MC	G	C	6	9.0	Y	Y	Y	Y	30	0.32	1.80	Black coating	4	14
East St. Louis	P	130.000			S	SC	G	Sh	18	10.8					42					11
							G	St	12	5.0					36	3.09	1.46			
							G	C	8	8.0					30	0.41	1.4			
Effingham	P	4.024		IR		C	G	C	3		Y	N								11
Eldorado	M	5.004	SR			C	P	Sh	2	0.7	Y(e)	Y	Y	Y	28					8
Elgin(f)	M	27.431			S	C	P	Sv	10	2.3										
Evanston	M	37.234			L	MC	G	C	6	12.0	Y	Y	Y							
Fort Sheridan	US				L		P	Sh	3	1.5										
Freeport	P	19.669			W	Soft	G	Wt	4	4.0	N		N		30					
							G	C	4											
Great Lakes Naval Training-Station	US			IR	L	MC	G	C	2	1.0	Y	Y	Y	Y	48	0.34	2.6			18
											Y	N			30	0.40	1.12			

Great Lakes Naval Training-Station	US				L		G				Y	Y			48	0.34	2.6			
Hamilton	M	1.698		IR		MC	G	C	2	1.0	Y	N	Y	Y	30	0.40	1.12			18
Harrisburg	P	7.125	SR			MC	G	C	3	0.9	Y				30				3	12
Herrin	M	10.986	SR			MC	G	C	2	1.0	Y	N	Y	N	28	0.49	1.17	Coating brown	3	12
Hinsdale	M	4.386			W	Soft	G	C	3	1.0	N		N		18					28
Jacksonville	M	15.713		IR		AMC	G	C	3	1.5	Y	Y	Y	Y	30	0.47	1.70			18
Kankakee	P	16.721		IR		C	G	C	8	4.0	N		N		36	0.60	1.67			6.7
Kenilworth	P	1.400			L	C	P	Sh	2	0.6	Y(e)	Y	N		36					
Lake Forest	P	3.363			L	C	P	Sh	2						18					
Lawrenceville	P	7.309			S	MC	G	C	2	1.0	Y	Y			30					
Macomb	M	6.714	SR			C	G	C	2	1.0	Y	N	Y	N	30			Black coating	5	14
Marion	M	9.582	SR			S(g)	G	Wt	2	1.16	Y	Y	Y	Y	23	0.35	1.68			13
Mascoutah	M	2.343			W	Soft	P	Sv	1											
Moline	M	30.734			S	C	G	C	5	5.0	Y	Y	Y	Y	30	0.39	1.36			15
Mt. Carmel	P	7.456			S	MC	G	C	3	1.5	Y	N	Y	N	30	0.32	2.0			13
Mt. Vernon	P	9.815	SR		S	MC	G	C	3	1.5	Y	Y	Y	Y	33	0.73	1.30	Black coating		18
Murphysboro	P	10.703			S	AMC	G	C	4	2.0	Y	N	Y	N	36	0.33	1.48		4.5	9.0
Pana	M	6.122	SR			MC	G	C	2	1.0	Y	N	Y	N	16	0.42	1.42			12
Pontiac	P	6.664		IR		C	G	Wt	3	1.5	Y	Y	Y	Y	48					
Quincy	M	37.000			S	C	G	C	6	6.6	Y	Y	Y	Y	24	0.40	1.31		2.5	14
Rock Island	M	38.000			S	C	G	C	6	6.0	Y	N	Y	N	24				4	12
Rock Island Ars	US				S		G	C	3	1.5	Y									20
Salem	M	3.457	SR			MC	G	C	2	0.6	Y	Y	Y	Y	27	0.35	1.88		4.0	15
Sparta	M	3 340	SR			MC	G	C	2	0.5	Y	Y	Y	Y	32	0.40	1.65			15
Streator	P	14.779		IR		SMC(h)	G	Sv	6	3.5	N		N		42	0.80	1.42		5	10
Warsaw	M	2,031			S	C	G	Wt	4	0.36	N		N		36	0.41	1.56			20
Total		642.900							194											

(a) Population obtained from total of various communities supplied. No estimate is available showing number of persons actually consuming water.
(b) Upper figures apply to west filter, the lower to the east.
(c) Not all rate controllers in service at last inspection.
(d) Not all loss-of-head gages in service at last inspection.
(e) Partial control secured thru operation of high service pumps connected directly to underdrains.
(f) River used for supplemental supply.
(g) Some preliminary sedimentation obtained in pond adjoining pumping station.
(h) Coagulant now added at two different points, effecting double coagulation.
Note: Fort Sheridan now gravity type.
Explanatory notation: W—wood; C—concrete; St or Wt—steel or wood tube; Sv or Sh—steel vertical or horizontal; N—no; Y—yes.

22 horizontal steel drums, both tanks and drums having once been used as pressure filters. In the 6 pressure-filter installations, there are 20 pressure-filter units, 9 horizontal steel drums and 11 vertical steel tanks. Nearly all of the rapid sand filters are designed for a rate of 2 gallons per square foot per minute or 125 million gallons per acre per day.

New filter installations or enlargements to existing plants, subject to the approval of the State Health Department, are usually of the gravity type. The department considers pressure filters unsatisfactory for public water supplies because the operator cannot observe the condition of the sand in the filters and the effect of washing. The interiors of the filters are not accessible for cleaning and repairs and high wash-water rates are used. When operated as gravity filters, as at East St. Louis and Streator, they have an advantage of having a capacity of considerable overload, which from a sanitary standpoint may not be desirable. At East St. Louis these horizontal drum filters handle about 10 million gallons daily or about 45 per cent of the supply. With both types of filters, it is possible, by comparison of the two effluents and the condition of the settled water, for the operator to know somewhat more about the condition of the pressure filters than would be possible if pressure-type filters alone were available.

At Eldorado, pressure filters were installed without adequate facilities for coagulation or sedimentation, there processes taking place in a small closed tank and coagulant added by a shunt-feed device. A plant of this character is exceedingly difficult to operate and at best the quality of the filtered water is doubtful.

Pressure filters installed at McLeansboro have been removed and the public water supply is not now treated.

In order to secure adequate filtration, the operator must be provided with some means of securing information concerning the condition of the filter units by loss-of-head gages or rate controllers. It is believed that one point in this connection is sometimes neglected in discussions of filter control, namely, the memory of the operator. In a small plant, with a few filters, some degree of control may be obtained through reliance on knowledge of operating conditions obtained through memory alone, but in a larger plant this is manifestly impracticable. Such a statement does not mean that both of these devices, rate controllers and loss-of-head gages, are not very desirable in a small plant. A good operator of a small plant may

secure satisfactory results with only one of these devices, but much better operating results may be obtained if the filters are provided with both devices. In larger plants, both devices are essential.

At many of the plants, the operators have never familiarized themselves with the construction of the rate controllers or the loss-of-head gages and, consequently, they are unable to repair either of the devices if a part is accidentally broken, or to reset them, in case they do not record accurately. The setting of a rate controller is usually a relatively simple matter, the rate of vertical drop in a filter being 3.2 inches when water is passing through the controller at the nominal rate, 2 gallons per square foot per minute. The engineers of the department endeavor to advise and assist the operators in overhauling the controlling devices, to place them in service and to indicate to them as forcefully as possible, the necessity of maintaining them in accurate and continuous service.

In recent literature, several articles have appeared relative to the most efficient size of sand for rapid sand filter plants. Dittoe[5] and Catlett[6] agree that the effective size should vary between 0.35 and 0.40 mm. with a uniformity coefficient from 1.5 to 1.8. The Ohio requirements, as outlined by Mr. Dittoe, give a preference to sand of 0.37 mm., effective size with a uniformity coefficient not exceeding 1.6, all particles to be finer than 1 mm.

Laboratory examinations of samples of sand, collected during the past 18 months from 18 rapid sand filter plants, show that the effective size of sands now actually in use ranges from 0.32 mm. at Decatur and Mt. Carmel to 1.45 mm. at Alton. The average effective size is 0.51 mm. and uniformity coefficient of 1.52. The effective size of 75 per cent of the sands will range between 0.32 and 0.50 mm.

At Alton, where lime and iron are used, the sand in the east filter has as effective size 0.87 mm. and the west filter a size of 1.45 mm., whereas the Redwing sand as originally installed in the east filter in 1915 had an effective size of 0.30 mm. and uniformity coefficient of 1.5. The growth has been largely due to accretions of calcium carbonate. At Anna State Hospital, the sand was black and was coated with a considerable deposit of lime with a large proportion of

[5] W. H. Dittoe, "Proper Size of Sand for Rapid Sand Filters." J. A. P. H. A., January, 1922, pps. 44–49.

[6] G. F. Catlett, "Operation of Mechanical Filter Plants," Paper presented before North Carolina Section, A. W. W. A.

iron and manganese. The sand as obtained from the filters had an effective size of 0.55 mm. and a uniformity coefficient of 1.13, while the effective size and uniformity coefficient of the washed sand was 0.50 mm. and 1.20, respectively. A portion of this water supply contains manganese, and the coating on the filter sand apparently may produce a reduction of manganese and possibly also of iron by means of an adsorptive effect.

In a discussion[5] of Mr. Dittoe's paper, Mr. Alexander Potter, a consulting engineer of New York City, states that this requirement of sand size caused considerable additional expense at Warren, Ohio, as well as delay in placing the plant in operation. He further points out that, if at one plant in Ohio the sand size has increased from 0.39 to 0.44 without sacrifice in bacterial efficiency, the specifications may be too narrow. The author feels that this objection may be well taken considering the growth of sand in filters and that more emphasis should perhaps be placed on the absence of very coarse or very fine material affecting both features of the size rating and more attention given to proper grading of the underlying gravel, rather than to place too great emphasis on exact conformity to fixed specifications for sand.

At a recent plant at Dallas City, installed without first submitting plans to this department, an air agitation of 20 minutes is used followed by a 4-minute water wash. For the most part, these systems with both air and water wash were installed at a time when it was believed that a wash-water rate of 4 to 8 inches vertical rise per minute was sufficient. Air agitation may be used if applied intelligently, but a careless or inexperienced operator may easily disturb the filtering qualities of a sand bed.

The higher velocity of wash water effectively stirs up the entire sand bed and thereby removes much of the tendency for mud balls to form and affords more complete washing of the sand bed. Where the wash-water distribution or collecting system is not properly proportioned, these higher velocities sometimes may not be used, in which case the filters should be overhauled and a new underdrain system provided. High velocity washing is not a cure-all, but the factor of rapid and thorough cleaning of the filter bed is of no slight importance.

The unsatisfactory quality of the filtered water obtained from several of the purification plants may largely be due to improper washing, either inadequate or excessive. If mud balls form or the

distribution of wash water is imperfect, some portions of the filters may be over-washed, discharging a waste water of low turbidity, while other portions may receive an insufficient amount of washing. Should the filter be over-washed, settled water containing coagulant must be wasted until a proper mat is formed on the over-washed portions. If the filters were washed uniformly, but the washing was stopped while the water was still somewhat turbid, the filter would be in better condition and less wash-water would be required.

Recent articles are again showing a trend toward simpler underdrain systems and have indicated that satisfactory underdrains may be made by the use of perforated pipe. An underdrain system of this character has been used at Harrisburg, Pennsylvania for 15 years. One possible objection to such a method is the clogging or corrosion of these orifices, which apparently does not constitute as serious a factor as the corrosion where brass strainers are used with iron pipe. The Wheeler filter bottoms and other devices of concrete with glass orifices are also in rather extensive use, with more or less success. In any case, careful design of the collecting system is essential in order that the quantity of water discharged from the various orifices might be as nearly equal as possible, affording equal rates of filtration or distribution of wash-water over the filter surface.

Sterilization. Of the 38 filter plants in Illinois, for which data are available, 9 now use calcium hypochlorite and 29 liquid chlorine. At Elgin, the highly polluted river water after filtration is chlorinated twice before it is discharged into the distribution system. Of the 17 places where sterilization is the only treatment, all but Waukegan use liquid chlorine.

The mere addition of a sterilizing agent without proper consideration of the point of application gives a false security. At Eldorado, Kenilworth, Macomb, Mt. Vernon and Rock Island, and until recently at Alton, the sterilizing agent is added to the settled water prior to filtration. At Rock Island the filtered water, sterilized previous to filtration, is stored in open basins subject to more or less accidental or malicious contamination, and under these conditions it is expected that analyses would give more or less inconsistent results.

At many of the plants, the sterilizing agent is added as the water enters the clear-water basin from the filters. At several plants, the water in the clear-water basin may become contaminated, as at Alton, Hamilton, and Mt. Carmel. The application of the sterilizing agent as the water enters the clear-water basin is not entirely satisfactory

unless the plant is properly balanced with respect to capacities of filters and clear-water basin and the consumption, and the clear-water basin is provided with suitable baffles to prevent short circuit of the sterilized water directly into the pump suction and to prevent the formation of "pockets" of water which has been sterilized several days previously. Such a condition seldom obtains on account of the necessity of providing reserve clear-water capacity to meet fire and other emergencies.

The quality of the effluent would vary, therefore, so that it is often desirable to add the chlorine to the pump suction so that it will be properly and thoroughly mixed in the pump cylinders. The addition of the sterilizing agent into the pump suction may cause corrosion, but, in a recent article,[7] of some 15 persons in charge of water-purification plants, only about 6 stated that corrosion would result, considering the small quantities used. A centrifugal pump might be more subject to corrosion than a piston-type pump. This does not, however, affect the desirability of providing the clear-water basin with suitable baffles so as to avoid conditions of stagnation or to minimize possible contamination.

At East St. Louis, a short circuit frequently obtains in the smaller clear-water basin in which the sterilizing agent is applied to the water as it enters the basin. It is possible that some of the water in the basin may remain stagnant for several days after the chlorine has been added. Similar conditions occur at Moline and Pontiac. At Danville, difficulty from overgrowths in the distribution system might be attributed to improper arrangement and operation of the clear-water basin.

Much of the problem of aftergrowth in the mains may be due to faulty arrangement or operation of the filters, clear-water basin and sterilizing equipment. These difficulties might be prevented by a careful study of the possible paths which water might take through the purification plant.

Difficulty in obtaining effective sterilization has been caused by improper installation of chlorinating equipment and by improper operation and maintenance of the equipment. In one case, little regard was paid to the actual capacity of the pumping equipment, the pump being operated at a rate equal to twice the daily consumption, but only during a period of 12 hours. Failure to provide a supply of extra parts for chlorinators and to make the operators familiar with

[7] Engineering News-Record, vol. 87, no. 10, September 8, 1921, p. 392.

the construction of the chlorinator to enable them to keep the chlorinator in service, even though some part is out of commission, are two essential causes of intermittent action of the chlorinators. The operators are warned that the machines are delicate but, for the most part, they have not been carefully instructed in regard to the more frequent causes of breakdown, such as leaky valves, clogging of tubing, etc. Wherever trouble is found, the engineers of the State Department of Health instruct the operators in the solution of these difficulties.

Proper records of the amounts of chlorine added and of water pumped should be maintained, especially for surface supplies where the chlorine absorption value of the water varies materially with changing weather conditions. The amount of chlorine added should be checked by recording the flow of chlorine through the measuring devices and by weighing the drums on platform scales. These records, with the results of daily or twice daily control tests for excess chlorine by means of ortho-tolidin, will enable the operator to add sufficient sterilizing agent with little danger of overdose and complaints of tastes and odors.

The results of tests for free chlorine obtained by the use of ortho-tolidin, as indicated in "Standard Methods," are not considered always reliable, especially in waters which contain nitrites, ferric salts, chlorates and probably other oxidizing agents. Relatively little has been written describing in detail the reasons for ortho-tolidin giving erroneous values. It has been suggested by Wolman[8] that free chlorine tests be made on the raw and sterilized waters and that by a comparison of the results, chlorine may be added so that an excess may always be present in the treated water. In this article, a 5-minute absorption period has been suggested to govern the amount of excess chlorine remaining in the water, but, at least for Illinois conditions, it seems more logical to allow a longer absorption period, varied in accordance with the distance of the first consumer from the purification plant, as it is believed that this period may not in all cases satisfy the chlorine demands of the water.

In cases of supplies purified by filtration, with or without chemical treatment, the raw water before chlorination may show a yellow color with ortho-tolidin and the ortho-tolidin tests may not be considered reliable because filtration may remove, under certain

[8] "Water Chorination Control," Abel Wolman. Engineering News-Record, vol. 86, no. 15, April 14, 1921, p. 639.

conditions, the color-producing material. Where bacteriological control can not be made available at once, ortho-tolidin tests on the filtered water prior to sterilization and on the same after sterilization may be made of considerable value. A surface supply, without purification other than sterilization, may be properly controlled by tests for free chlorine on the raw and sterilized water, providing a large excess of free chlorine is maintained or consideration is given to a sufficiently long absorption period.

LABORATORY CONTROL

It is now generally agreed, by those who have studied water-purification plants, that careful and continuous analytical control is necessary if an effluent of proper physical appearance and sanitary quality is to be available at all times and if the plant is to be operated economically. A purification plant is not properly operated if water of unsatisfactory appearance is being delivered at any time and certainly is not entitled to as high a rating as a plant giving an effluent of satisfactory appearance at all times. The same is true of the sanitary quality.

Laboratory control can be divided into (1) control of the purification processes by periodic analyses made by the State Health Department and (2) control by analyses made locally by nontechnical filter operators or by technical operators or chemists or bacteriologists. At one time the former method was believed to be fairly satisfactory, but in the past few years it has become increasingly evident that each plant must be regarded as a separate entity and operating conditions are not the same at any two plants. The State Health Department may make periodic analyses to check the operation of the plants, but continuous satisfactory operation is not probable unless some daily tests are made at the plant.

One of the principal objections against local laboratory control, that of expense, has been largely removed since pressure cookers for home use, built in a manner similar to steam autoclaves, may be obtained now at a price of from $15 to $25. A horizontal steam autoclave of satisfactory design varies from $110 to $250 and an Arnold sterilizer requiring three successive days for sterilizing culture media is as inconvenient as the steam autoclave was expensive. Small incubators made of wood, lined with non-conducting material, such as transite or asbestos wood, may be obtained for $15 to $30, or a small egg incubator may be used with a kerosene lamp, providing

the fumes from the lamp do not enter the incubation chamber. If electricity is available, heating units complete with thermostatic control may be purchased for about $12, or a homemade device consisting of carbon lamps with a "Mesco" thermostat may be obtained for $2 or $3.

The Division of Engineering and Sanitation has prepared a list of apparatus required for the control of sterilizing processes, including bacteriological and ortho-tolidin tests, the cost of which, complete with steam pressure cooker and incubator, would not exceed $150. For filtration plants, an expenditure of $20 to $30 additional, would cover the apparatus needed for the other purely chemical tests.

It is desirable that, wherever possible, the services of a trained sanitary engineer, chemist, or bacteriologist, be made available, not only for water-purification plant control but for other work of a public health nature in a community. In the smaller plants, this is generally out of the question, but in many instances the science instructors at the high schools might be engaged to do such work. Several plants are now planning to install laboratory control, tests to be made by one of the officials of the water company or by some person under their direction.

The State Department of Health considers tests for control of a complete purification plant to include turbidity, alkalinity to methyl orange, bacterial counts on agar at 37 degrees, gas formers in 10, 1.0, and 0.1 cc. portions, and tests for free chlorine, by use of ortho-tolidin.

Additional information concerning the efficiency of the various stages of the purification may be obtained by the use of the 20-degree count on agar, by the determination of color (where of importance), and by chemical or physical tests to determine the effect of alum or other coagulants.

Hydrogen-Ion Concentration. Recent developments in the study of hydrogen-ion concentration of various waters have pointed strongly to the further necessity of adequate local control of these processes and is apparently pointing the way to the solution of many of the difficulties in purification plants. At the Montebello plant at Baltimore, Maryland, this test has proven of decided value in controlling corrosion. These determinations are being made at only one plant in Illinois, at Mt. Vernon, under the direction of W. F. Monfort, consulting chemist, St. Louis. It is hoped that at a later date he will present some of this information at one of our meetings.

Just a word of caution to persons making their own culture media. It must be made from satisfactory constituents, properly and carefully prepared, otherwise the results may not be comparable with those obtained from other laboratories. The dehydrated culture media now on the market seems to be satisfactory, at least for lactose broth and plain agar, but some of the media containing dyes frequently do not give satisfaction.

The purification plants and sterilization plants where laboratory control are now available are shown in tables 6 and 7. An effort has been made to indicate the degree of control, showing whether or not the State Department of Public Health considers it entirely satisfactory or only partially so. It is believed that, if records for 1916, when the Division of Engineering and Sanitation was created, were available, a substantial improvement would be indicated by present records.

Forms are now in preparation by the State Department of Health for a more complete report than that now furnished by some of the plants. The forms for filter plants will consist of a monthly sheet to contain results of daily analyses and other daily operating data and a yearly summary sheet. The forms for plants with only chlorinating equipment will be similar, but with a smaller amount of data and are to be furnished weekly, together with a monthly summary. These record forms will give information which the State Department of Health regards as essential and data of local importance, either to the municipality or to the filter company operating the plant, and they will not be burdensome to maintain.

STANDARDS OF PURITY FOR TREATED WATERS

The standards by which the purity of a drinking water are to be judged in various sections of the country are unfortunately still rather too numerous. The Treasury Department standard, prepared by a commission of experts during 1914, has done much toward the coördination of standards governing the bacteriological quality of a water. In a recent article,[9] C. Arthur Brown has suggested that the 37-degree count used in this standard is unsatisfactory for water-purification plants and further that it was not designed to cover waters of this general class. From the experience of the Department in its coöperative supervision since 1918 over some 20

[9] C. Arthur Brown, Engineering News-Record, September 1, 1921, p. 353.

TABLE 6

Laboratory control of water-purification plants

TOWN	LOCAL LABORATORY CONTROL				PURIFICATION RECORDS	CLASS	SANITARY QUALITY OF WATER
	Complete	Partial	Free chlorine	None			
Alton	*		*		*a	B	Doubtful. Safe if properly chlorinated
Anna State Hospital		*	*			B	Good. Safe if properly chlorinated
Breese				*		E	Bad. Inadequate purification
Cairo		*			a	B	Good
Carlinville				*		E	Doubtful. Inadequate purification
Charleston			*	*	a	C	Doubtful. Safe if plant is properly operated
Dallas City			*			C	Good. Safe if plant is properly operated
Danville	*				*a	A	Good
Decatur	*		*		*a	A	Good
East St. Louis	*		*		*a	A	Good. Preliminary treatment insufficient
Effingham		*	*		*a	B	Good
Eldorado			*?			C	Doubtful. Inadequate purification
Elgin		*	*			D	Doubtful. Safe if properly chlorinated
Evanston		*	*?		*	B	Good
Fort Sheridan		*?		*?		B	Good
Great Lakes Naval Training Station		*?	*?			B	Good
Hamilton			*		a	C	Good
Harrisburg	*		*		*a	A	Good
Herrin			*		a	C	Good. Plant somewhat overloaded
Jacksonville		*	*		*a	B	Good. Plant overloaded
Kankakee		*			*a	B	Good
Kenilworth		*				D	Good. Safe if properly chlorinated

TABLE 6—*Continued*

TOWN	LOCAL LABORATORY CONTROL				PURIFICATION RECORDS	CLASS	SANITARY QUALITY OF WATER
	Complete	Partial	Free chlorine	None			
Lake Forest				*		E—	Good
Lawrenceville	*		*		*a	A	Good
Macomb		*				D	Good
Marion			*		a	C	Doubtful. Safe if properly chlorinated
Moline	*		*		*	A	Doubtful. Plant overloaded
Mt. Carmel			*		*?a	C	Doubtful
Mt. Vernon		*	*		*a	B	Good. Plant overloaded
Murphysboro	*				*a	B	Good
Pana			*			C	Doubtful. Safe if properly chlorinated
Pontiac		*				D	Good
Quincy	*				*a	A	Good
Rock Island	*				*a	B	Good. Contamination after sterilization
Rock Island Ars				*?		E?	Good
Salem		*	*		a	B	Good
Sparta		*	*		*	B	Good
Streator	*				a	A	Good
Warsaw			*		*a	A	Doubtful. Inadequate purification

"Complete" control includes bacteria and gas formers, together with chemical determinations on raw water.

"Partial" control includes whole or part of above tests, but not made with sufficient regularity to provide satisfactory control.

"Excess chlorine" either by ortho-tolidin or starch iodide.

"Records" refer to complete data concerning purification processes, chemicals added, wash-water used, etc.

"a"—Operating results checked by analyses by State Department of Health at regular intervals from 14 to 90 days.

Class A: Adequate and continuous laboratory control so that water should be delivered at all times satisfactory.

Class B: Fairly complete laboratory control, but analyses insufficient in frequency or detail, to secure a satisfactory water at all times.

Class C: Tests for excess chlorine only, made regularly and as good control of water as is possible with this single test.

Class D: Partial laboratory control but not sufficient for proper control of quality of water.

Class E: No laboratory control so that an unsafe drinking water may be delivered to consumers under unfavorable conditions.

public water supplies obtained through purification plants and used on common carriers, it has been shown conclusively that a properly designed and operated plant may consistently meet this standard in the final effluent. There are, however, some points in the interpretation of the wording which are not entirely clear and with the additional data now available might well be altered so as to be clearer.

Much has recently been written concerning the presence of "spore-formers" which are not affected by chlorine, in the effluent of water-purification plants. Several epidemics of enteritis have elsewhere been attributed to these organisms, but thus far the evidence against these spore-formers is not conclusive. The epidemic at Montclair, New Jersey, in December 1920 was probably the most widely known of these outbreaks. The term "B. welchii" is often loosely used for all spore-formers, but it is probable that only a very few of the organisms found may actually be classified as B. welchii. A recent interesting editorial in the American Medical Journal[10] suggested that (*a*) if a water is suspected of containing a large amount of sewage contamination, preliminary treatment, other than chlorine, should be used: (*b*) the evidence presented in the summary in the *Engineering News-Record*[11] was insufficient to determine whether or not the bacillus coli test for contamination was adequate: (*c*) additional cultural and classification data concerning the "stormy-fermenters" are necessary: (*d*) the suspected organisms (at Montclair, New Jersey) were not shown to be the cause of the gastro-intestinal disturbances to which reference was made.

More study should be given to these spore-formers in all supplies where they are found by State health departments or research laboratories along the lines of the preliminary investigation made by Hinman and Levine,[12] A re-classification should be made by technical bacteriologists of all these organisms, differentiating the various groups and removing the confusion now caused by overlapping and indeterminate classification now used.

ILLINOIS STANDARDS OF PURITY FOR TREATED WATERS

It is the policy of the State Department of Health to consider that each portion of a plant should bear its share of the burden, the

[10] Jour. American Medical Assn., vol. 78, no. 4, January 28, 1922, p. 283.
[11] Engineering News-Record, vol. 86, no. 929, 1921.
[12] Journal American Water Works Assn., vol. 9, March, 1922, p. 330.

TABLE 7

Laboratory control of sterilization plants

TOWN	OWNERSHIP	STERILIZING		LOCAL LAB. CONTROL		CLASS	SANITARY QUALITY OF WATER
		Agent	Operation	Complete	Free Cl.		
Regular use							
Benton	P	C	Continuous		*	C	Good
Carbondale	P	C	Continuous		*	C(a)	Good
Centralia	M	C	Continuous?		*	C(a)	Good. Safe if properly chlorinated
Chicago	M	C	Continuous	*	*	A	Good
Christopher	M	C	Intermittent			E	Bad. Chlorine not regularly used
Duquoin	P	C	Continuous			C	Doubtful. Safe if properly chlorinated
Highland Park	M	C	Continuous		*	C(a)	Good
Nauvoo	M	C	Continuous		*	C	Doubtful. Safe if properly chlorinated
North Chicago (c)	M	C	Intermittent			E	Bad. Lake water not purified
Paris	M	C	Continuous		*	E	Doubtful. Safe if properly chlorinated
Tuscola	P	C	Intermittent			C	Good. Safe if properly chlorinated
Watertown Hospital	State	C	Intermittent			E	Doubtful. Safe if properly chlorinated
Waukegan	M	H	Continuous	*?	*	B?	Doubtful
Winnetka	M	C	Continuous		*	C	Good

Emergency use

Aurora	M	C	Intermittent	*	*	A (a)	Doubtful. Possible contamination after discharge from wells
Freeport	P	C	Intermittent	*	*	A(ab)	Doubtful. Affected by high water
Peoria	P	C	Intermittent	*	*	A(a)	Good. Affected by high water
Springfield	M	C	Intermittent			D(a)	Good. Affected by high water

(a) Operating results checked by analyses by State Department of Health at regular intervals from 14 to 60 days.
(b) Chlorinator supplemented by complete control tests will be installed within a short time.
(c) Part of supply from lake only requires chlorination.
Class A: Adequate and continuous laboratory control, etc. (see end of table 6).

preliminary processes as well as filtration and sterilization. The chlorinator is considered as a true factor of safety and not as an integral part of the purification process. If the filters are turning out a water of poor quality, the dosage of chlorine may be increased, resulting in a water of poorer quality and possibly causing tastes or odor. The quality of a filter effluent will depend on the raw water and some allowance can be made for abnormal conditions, which reduce the efficiency of the preliminary treatment.

Under average conditions, our experience has indicated that a good filter effluent should not show gas in any of the 1 cc. or smaller portions, after 48 hours' incubation, but may show gas in the 10-cc. portions in not to exceed one or two tubes after 24 hours and possibly in all five tubes after 48 hours' incubation. Some weight is also placed on the results of the partially confirmed tests on Endo's medium. The bacterial count may show a rather wide variation and less weight placed on this determination.

The quality of the final effluent after sterilization is judged by samples collected at the plant and also from the distribution system. The samples collected at the plant, should show a low bacterial count, no gas formation on presumptive test in the 1-cc. portions and in not exceeding two 10-cc. portions even after 48 hours' incubation.

An "aftergrowth" may and usually does occur in the mains. Samples collected from the distribution system may show gas in all five 10-cc. portions, but only after 48 hours' incubation. Such gas formers will almost always be negative on Endo's medium. This standard is not rigorously applied, but if a majority of the plants meet these standards on daily analyses or on analyses of samples collected at regular intervals, the standard is not too rigid.

To bring forward an idea which is far from new, the Committee on "Standard Methods of Water Analysis" should investigate and draw up suggestions for a suitable liquid culture media for the detection of gas-forming organisms used in a manner similar to lactose broth, whose composition and inhibiting action will be such as to approximate the combined results of the presumptive and confirmatory tests. Brilliant green used by Dr. Hale at the Prospect Hill Laboratory at New York City, apparently is satisfactory. The difficulties with Endo's medium and with eosin-methylene blue agar to a lesser degree are sufficient to make it undesirable to suggest the use of them to any operators, unless they are trained bacteriologists or chemists. The simplified medium would have much to recommend it.

WATER COLLECTIONS[1]

By E. MacDonald[2]

A short sentence, if properly analyzed, will prove to be the only compelling force behind all public water supply organizations, no matter what their scope, size or location. "Water collections" is the remote reason which causes the dreamer to visualize a water supply system. It is the incentive which urges the promotor to organize a company and to work out the preliminary plans. It is the driving power behind the engineers, architects, and others who build a water supply system, and finally it is the only motive which urges on the people who operate such a system, excepting perhaps the local manager, who, of course, works for the sheer joy and satisfaction of serving his fellow beings, and the small portion of the water collections which he receives as a salary may be considered barely sufficient to repay him for the criticism and censure which is heaped upon him by those whom he serves.

I believe that the term "water collections" is a misnomer, because in my opinion water itself is as free as the air we breathe, and when a public water supply company charges its consumers for the service it renders them it really does not charge them anything for water. It charges them certain sums for transporting the water from its location as fixed by nature to the premises of a customer, I believe the proper term to be used by a water supply company should be "service collections," rather than "water collections."

Probably all water supply companies have from time to time endeavored to impress upon their customers that they are not charging anything for the water itself. If the customer would go to the original source of supply and obtain the water, it would be absolutely free. The water supply company is merely charging them for the service performed in carrying the water to them. The writer believes that, if the average patron of a water supply company can be sold to this viewpoint, he will be better satisfied with the service he receives and the charges he is asked to pay therefor.

[1] Presented before the Illinois Section meeting, March 30, 1922.

[2] Lincoln Water and Lighting Department, City Hall, Lincoln, Ill.

The original water supply organization probably consisted of a man, a pack animal and a couple of goat skins made into sacks. This organization would proceed to some stream, lake, or other natural source of supply, the goat skins would be filled with water, and carried upon the back of the pack animals to the door of a customer, where it would be measured out into some primitive vessel, and the charge for transporting it would probably be collected at the time of delivery.

Modern water supply organizations cannot collect on delivery, because the delivery of their services is practically constant. They must collect payment for their services, therefore, either in advance or in arrears. Where service is furnished on the flat rate or estimated basis, the collections are generally made in advance. Where service is measured by meter, collections must be made in arrears. I suppose no two water companies have a scheme identical in all details governing service collections.

The only company with whose method I am at all familiar is the Lincoln Water and Light Company. Perhaps its method will be of interest to you. This company is a consolidation of three, a water company, a gas company and an electric light company. All services of this Company are practically 100 per cent metered. Until just a few years ago each of the three departments kept its books separately from the others. Each department had its own meter reader, its addressograph list and account numbers, its own consumers ledgers, etc. All the accounts came due on the first of each month, with a ten days discount period. This resulted in a tremendous rush of work toward the end of each month, with a corresponding lull during the middle of the month.

Then we decided to try to improve our system. To do so we arranged our present plan of collections. We began with the addressograph list, discarding all duplicate plates and retaining one plate only for each individual consumer. By doing this we eliminated considerably more than one-half of the addressograph list, reducing the number of plates from approximately 5000 to a combined list of about 2200. Then we made use of a city directory, which had just been issued and was practically correct, sorting the addressograph plates as the consumers premises are located on east and west streets only. We eliminated all north and south streets from our records. Beginning at the western end of the most southerly street, we gave the first consumer account 1, the next consumer east of

account 1 became account 3, the next one account 5, etc. Each north and south intersecting street was included, in its order, for one block only to the north. We used odd numbers only in our first lay-out. We platted from west to east on the first street then east to west on the next street on the north. The third street was platted from west to east, the next from east to west and so on, including in the platting each street the first northern block of each intersecting street. Odd numbers were used in order to supply account numbers for additional consumers taken on in the future. For example, a new consumer obtained between account 1 and account 3 would be given account 2, then one between account 2 and account 3 would be given account 2A, etc.

After the consumers account numbers had been so arranged we instructed one man to read all the meters and in reading the meters he follows the account numbers absolutely. He works from west to east on the most southerly street, then east to west on the next street and so on. We had all meter reading sheets ruled and printed alike, but used different colors for the different classes of services. A white sheet was used for water consumers, a yellow for electric consumers, a blue for electric power consumers and a pink for the gas consumers Where a consumer uses more than one, or all classes of services, his meter sheets are arranged in the field book in the following order, water, electric light, electric power and gas. All sheets for any one consumer bear the same account number. The consumers ledger sheets are arranged in the same manner, although we do not use different colors for the ledger sheets, which are white. They are all ruled and printed alike. The various classes of services are distinguished by stamping on each sheet a large letter as, W for water service, E for electric lighting service, P for power service, and G for gas service. The same account number is stamped on all sheets applying to any one consumer.

We devised a combined bill form on which the meter readings, dates and charges for all services may be placed, using the back of the bill on which to show all the block rates for all classes of services. The upper line on the bill is devoted to water service, the next line beneath for electric business service, the next electric residence service, and the next for power service. All these lines have rulings showing the amount consumed at first, second, third, fourth and fifth rates. Blank lines are shown on which all small items of electric or water, gas service, gas merchandise and coke may be charged.

The bill was so ruled because our block rate for water contains three steps, for commercial electric lighting four steps, for residence electric lighting two steps, for electric power five steps and for gas four steps. By arranging a combined bill, as we have, all charges for all services may be entered upon one sheet of paper. This form of bill scarcely complies with the Illinois Public Utilities law requirement, which specifies that all charges for services rendered must be itemized on the face of the bill. We compromised with that ruling by printing upon the back of our bills all of our block rates for all classes of services showing the gross and net amounts, the various minimum charges and the discount period. We find that practically all our charges for any one premises may be entered upon one of these bills and, of course, is done under one account number. Very rarely will we have an extensive merchandise bill which can not be itemized on this bill form, and for those rare cases we use a bill head statement sheet.

We divide the city into three nearly equal districts, dividing the total number of consumers as nearly as possible into three equal bodies. The first district is billed on the first, the second on the tenth and the third district on the twentieth of each month. Each district has a ten days discount period. This resulted in an even balancing of our office work, in so far as the billing and collecting is concerned. The meter reading and billing is continuous. The reader will complete perhaps two streets in one day. The completed sheets are turned into the office and a clerk makes out the bills. Those bills are distributed by hand, the distributor following the same route as the meter reader does. One man cannot read all the meters, yet it is not enough work to keep two men busy, but, by a little switching about, two men read all the meters and distribute all the bills.

We now send out approximately 3000 bills per month, covering 2017 water, 1363 gas, 2065 electric light and about 200 merchandise accounts, making a total of 5645 accounts which are taken care of with 3000 bills.

We have earnestly endeavored to persuade the United States Post Office department to allow us to mail our bills for a penny postage. They will not do so because there is pen and ink writing on the bills. Two cent postage would cost us about $65.00 per month and we can deliver by hand much cheaper.

Our billing clerk has tables of various sums, of all amounts and classes of services, placed on an easel, so that no calculations are

necessary in making out the bills. The spaces on the bills are arranged in the same order as are the leaves in the meter reading books and in the consumers ledger. After the bills are made out they are posted and are then ready for delivery, but they are always kept in order according to the account numbers so that no sorting of the bills is necessary. We insist on delivering each bill at the premises where the service is rendered, making exceptions in cases of governing bodies or out-of-town parties. All exceptions are listed and located by account numbers.

Each day the receipted stubs are arranged by account numbers and posted. The only time the consumers accounts are handled separately is when adding up the days receipts. The water collections are first added, then the stubs are again handled and the electric collections are added, followed by the power, gas and finally the merchandise collections. All totals are then added and must equal the total cash receipts. Each month the books are proven by adding total revenue as posted and checking with total collections. this is done by one operation. We have three adding machines. One clerk handles the ledgers, calling off various amounts, example, water $1.00, electric $2.00, power $3.00, gas $4.00. The water accounts are listed on one adding machine, electric lighting on a second, gas accounts on a third and power accounts, being not very numerous, are first listed on a sheet of paper with lead pencil and afterwards added on one of the machines. We add up the total monthly consumption for each department in the same manner.

When we first installed our present system we had numerous objections from our customers, especially the merchants whose residences lie in one district and whose business houses are in another district. They objected to making payment twice a month. Many of the merchants desired that we should deliver their residence accounts at their places of business and a number of the landlords practically demanded that the water bills for tenant houses should be delivered to them rather than at the tenant house. We managed in a short time to overcome practically all such objections, generally by showing the customer all the different steps of our plan, explaining to them and finally convincing them that any break in our plan, such as they desired, while it would confer a small favor upon them, would subject us to a great deal of extra work and would increase the chance of making errors. At the present time we are delivering all bills at the premises where the services are used, with the exception of about fifty bills. The majority of those fifty are on such institutions as churches, public schools, lodges, etc.

INCENTIVE FOR EFFICIENCY IN THE MANAGEMENT OF PUBLIC UTILITIES[1]

By E. E. Bankson[2]

The purpose of this paper is to suggest concerted action by water works men to create greater economy and higher efficiency on the part of utility managers and operators.

Within the past few days the *Engineering News-Record* sent out a circular letter with this opening statement, "It's second nature with engineers to be *on their toes.*"

Mr. Finley is author of the statement that he "would not be true to his engineering profession if he did not operate his water department as economically and efficiently as possible." The basic ideal of the engineer, by training and nature, is toward economy and efficiency. It is in this spirit that we approach the present subject.

The speaker realizes we are treading on delicate ground, especially with respect to increasing costs, but if progress is to be made we are compelled to face the facts as we find them. It should be remembered also that any remarks directed towards government departmental practices are made only with constructive intent, and we should keep clearly in mind that the Public Service Commission is a creature of the law which created it and it is the duty of the Commission to apply the law of the State. The Commissioners are not free to operate as they might, if they were not guided by law.

In searching for a solution to our problem, we should bear in mind the reason for the type of management at different kinds of plants. A private company is in existence in order that a net revenue be obtained for the stockholders or the owners, and an appeal may be made to the management of a private plant successfully through the item of "Net Revenue."

The reason for municipal ownership and operation is to provide service for the inhabitants and the activities of a City. Sufficient

[1] Presented before the Central States Section meeting, Pittsburgh, November 3, 1922.

[2] Consulting Engineer, with The J. N. Chester Engineers, Pittsburgh, Pa.

desire should exist, therefore, that this service be provided at a fair cost. It is reasonable to assume, however, that for the average case the net revenue idea would not be so effective, to this end, as with the average private plant. We must look further for our source of incentive and the key may be found in the pride of the public servant responsible for the particular utility, or in the desire to make his position more secure. This latter avenue may prove equally effective in case of the private plant.

From the standpoint of incentive for economy, we may classify public utility plants as follows:

1. In case of private plants having a low revenue, there is sufficient incentive for economy, which is necessary if even a meager net revenue is to be provided.

2. For private plants operating under adequate revenue and usually in doubt as to the favorable outcome of a complaint filed against their rates, there is the tendency to keep the operating expenses reasonably high as a support for the rates filed.

3. Many municipal plants are being operated efficiently, because the necessary incentive is present in one form or another.

4. Many other municipal plants, however, are grossly mismanaged. Certain politicians may be more concerned with giving jobs to their supporters than with economy. The Department head may be hampered by certain existing conditions or by a blessed ignorance of the principles of economy.

There is probably a further condition which has a material bearing on this question and which results in a psychological reaction against unreasonable government control. Possibly this idea may be more clearly indicated by quoting from remarks made by Col. Spanger at the Pennsylvania Water Works Convention.

> I am encouraged to come to this water convention and find out all I can about a water company law, water company methods, and water company experience. I never saw so much legal learning and scientific engineering exploited as in this gathering, and all free. I must confess, however, that although I practiced law for twenty-five years and then was compelled to retire to look after private business, the importance of lawyer and engineer are increasingly necessary from year to year on account of bureaucratic regulations.
>
> The end is not yet. There are still numerous matters which have not been bureaucratized, but will receive their proper legal baptism in future legislatures, both at Washington and Harrisburg.

Probably every man here today has experienced at some time resentment against restrictions placed on his ordinary daily activities. In many cases he is so encumbered with rules and regulations requiring him to toe the mark in such a confined space that his individuality has little opportunity to show itself. On the other hand, you may keenly realize what splendid qualities may be displayed and what untold results may be accomplished by a capable man, unfettered by petty restrictions, where the sky and his responsibilities are the only limits. Restrictions, at every turn, take the heart out of man, while responsibility, with freedom, puts heart into man.

We should not criticise probably the older men in charge of our government bureaus, for they are generally able men and of sound judgment, but just criticism is sometimes well directed against certain details of the law under which a bureau operates. It is sometimes true that young and inexperienced employees of a government department may be fresh and over-bearing with their personal criticism and suggestions.

The foregoing references to restriction versus freedom are not prompted by personal experience, but are given to serve as the preliminary mouthpiece for those who may have something further to say on this topic.

Coming now to the question of economy, and dealing first with the private plant, it is possibly near the truth to say that the rules and practices of various public service commissioners must create and maintain an incentive for economical plant operation, or otherwise we are heading towards increasing inefficiency, carelessness, and extravagance.

A water company files request for an increase in rate schedule, and in order to have a little more assurance that the new schedule will be well supported by the facts, the manager often and logically permits the expenditure of a little more money here and there than he would sanction under other conditions. At the same time, these added costs may be of such a nature and in such amounts as to be entirely obscure from any criticism by the Commission.

The Commission may penalize the exceptional case of extravagant operating cost, but they can hardly penalize the case of average efficiency. This average efficiency may go from bad to worse, if there is no compelling reason for its not doing so. Commission orders, or coaxing, or driving will not bring ultimate success. There must be an incentive in order to produce desirable results. The point we

wish to make is that the public utility men have lost or will lose interest in economy and efficiency if they are not permitted to profit thereby.

A brief study has been made of the more outstanding items in Commission control, for the states incorporated in this section (as an example), in an effort to discover practices which give positive encouragement for economy. We are pleased to discover growing recognition in that direction.

We desire to acknowledge that the table herein included (table 1) has been prepared through the kind assistance of the Chief Engineers to the Commissions, for the States quoted. The actual tabulation is an interpretation by the writer from written discussions by these Chief Engineers. While the results here shown may not always be a fair interpretation of the average practice of the Commission in question, they certainly do not represent inflexible rules of the Commissions.

Your attention is directed to some features of the practice for each state, as indicated by table 1.

Indiana: The specific ten year period used by the Indiana Commission, to determine plant value, is not considered by them as conclusive and is used with judgment. The law provides that all pertinent information may be considered. With respect to going value, the law says the cost of bringing the property to its then state of efficiency shall be considered.

Ohio: The law states that the monies in the depreciation fund may be used for extensions, etc., or if invested, the income from the investment shall also be carried in the depreciation fund. The latter part of this statement is in keeping with the sinking fund theory of depreciation and with the theory of retaining the depreciation fund in the rate base, although neither of these ideas are followed by the Ohio Commission in this way.

Pennsylvania: The practice of the Pennsylvania Commission in considering original cost, undepreciated, is in keeping with the idea of retaining depreciation reserve in the rate base, but the idea is not carried beyond this point by the Pennsylvania Commission.

West Virginia: If original cost is used by the West Virginia Commission as the basis for plant value, it is depreciated in the same way as for reproduction cost estimates. The practice, for said state, of intending that there shall be an actual reserve fund, together with the practice of not considering this reserve fund a part of the rate base, means that the reserve fund shall provide its own revenue for the purpose of paying a return to the stockholder for that portion of his investment.

Looking now for a source of incentive, under item 3, in table 1, we find no reward offered by any of the Commissions, for the replace-

TABLE I

Comparison of commission practice

ITEM OF PRACTICE	INDIANA	OHIO	PENNSYLVANIA	WEST VIRGINIA
1. Control over municipal plants	Ordinance by appeal	Information	Generally none	Complete*
2. Control over private plants	Complete*	Except prior contracts*	Complete*	Complete*
3. Plant valuation:				
Price formula	Averages 1911–1920	5 year average†	Fair value	Hist. repro. cost
Depreciation method	Sinking Fund	Straight line	No standard	As warranted
Obsolete by inefficiency	Balance amortized	Excluded	Excluded	Excluded
Cost of financing	Operating cost	No	Computed	For bonds
Going value	Included	No	On merits	As preliminary
Original cost depreciated	Original not used	Original not used	No	Yes
4. Common rate of return	8 per cent	8 per cent (N. Gas 10 per cent)	7 per cent	6 per cent
5. Annual depreciation allowance:				
Method computed	Sinking fund	Straight line	No standard	As warranted
To create actual reserve	Yes	Intended	Not intended	Intended
Is reserve part of rate base	Yes	No	Not intended	No
6. Are reports required	Yes	Yes	Soon	Yes
7. Operating Expenses:				
Is efficiency rewarded	Yes	No	Law provides	No
Commission to decrease rates with operating costs	Yes	Not usual	Close scrutiny	If desirable
8. Can new rates become effective without commission permission	No	As prescribed	As prescribed	No

All practice is subject to requirements of the case.

* With certain minor exceptions.

† The law provides "As of a date certain."

ment of inefficient plant items. Indiana intends that the Company be permitted to amortize the remaining value in such replaced equipment, but in other states where the company is even penalized, the plant manager might often continue the operation of inefficient equipment, rather than lose credit for remaining investment in same.

Under item 7 we find some food for thought, as related to the present subject. We find that one Commission does recognize efficiency. The Indiana Commission rewards efficiency and economy by permitting a higher rate of return where such conditions exist than where conditions are less commendable.

In this connection we might add that the North Dakota Commission has recently said:

> That a company which is on the alert to practice economies should have some part of the saving, else there would be no inducement to reduce the cost of service.

In the case of the Huntington Water Corporation, the West Virginia Commission said:

> The applicant has been operating its plant efficiently and economically. Good service should always be considered in fixing the amount that a utility is entitled to earn.

The Virginia Commission has voiced a corresponding idea regarding incentive, although with respect to value of water rights, and we quote only that part of the opinion which especially incorporates the idea of the subject at hand.

> The investors are entitled to a return upon their foresight and their enterprise, ... Otherwise, there would be no incentive for the exercise of initiative and vision. . . . . In fixing the value of water power the Virginia Commission allowed the Company a sum, on account of its water rights, which approximately divided the net saving, due to the use of the Water Company's water power, between the Company and the public.

It is unnecessary, therefore, to say that efficiency and economy *should be* recognized, but we can say instead that efficiency and economy *are being* recognized by many Commissions. It must be remembered, however, that a public utility must submit full evidence as to economies and efficiencies before it may expect the Commission to recognize the same. The Commission sits as a court to hear the case, and not as lawyers or engineers to present or develop a case.

Possibly the Pennsylvania Public Service Commission law holds the key to the situation, where it provides,

† The law provides "As of a date certain."

> That it shall be lawful for every Public Service Company . . . . to participate, to such an extent as may be permitted by the Commission, and deemed by the Commission wise, for the purpose of encouraging economies, efficiencies, or improvements in methods of service, in additional profits which will be afforded by such economies, efficiencies, or improvements in methods of service.

which, for clarification might be read as follows:

> That it shall be lawful for every Public Service Company . . . . to participate in additional profits which will be afforded by economies, efficiencies, or improvements in methods of service, to such an extent as may be permitted by the Commission, and deemed by the Commission wise, for the purpose of encouraging such economies, efficiencies, or improvements in methods of service.

The real importance of this problem is in a practical effective method of making a division of the extra profits which may be created by economies and efficiencies.

As each Commission might initiate and adopt this idea of "Reward for Economy," they would probably also feel capable of defining the methods to be used. From a glance at table 1 we may reasonably conclude that each Commission would adopt a different policy, at least as to detail, and if we are to have any uniform idea of the methods used by different states, it is evident that some centralized body must do the missionary work as to standardization.

The speaker realizes how futile it may be to offer suggestions which do not yet have sufficiently general support to insure success, but if no suggestion is made, as to a possible or practical solution, we have left the subject of this paper suspended in midair. The practical solution in the case at hand might be the establishment of "Standards of Cost" to serve as a guide in fixing rewards, and such standards would surely serve to encourage operators of municipal plants.

Some centralized body would establish standards of cost for each of the various operating expenditures of a utility department, with which similar costs, for the case in question, might be compared. For this work of standardization there is certainly no organized body nearly so well prepared as the Standardization Council of the parent body of this organization. This would mean that the Standardization Council should create an additional permanent committee for this purpose.

The question naturally arises as to how such activities would be beneficial to municipal plants. We shall point out here the possi-

bility offered by such "standards of cost" through the impression which is made on the management of the municipal plant. This would offer a Standard for comparison, widely known to all active utility men and public officials, a standard by which any utility man might compare his operating costs with others. The knowledge that he was either above or below such a standard might spur him on to greater efforts. Such standards available for comparison of costs by the chief executive of a municipality would cast reflection or credit upon the official in charge of such a department. A positive incentive for economy, affecting either the pride of the manager or the security of his position, would result. The real advantages of such a program are:

1. Money saving for patrons of public utilities.
2. Increased net revenue for public utilities.
3. Provision of standards of cost towards, and below, which all operators might strive.
4. The correction or removal of a fundamental ailment, namely, "Lack of Incentive for Economical Operation."

THE REACTIONS OF CULTURE MEDIA: PART 2[1]

By George C. Bunker[2] and Henry Schuber[3]

The object of this paper is to bring up to date our first paper on "The Reactions of Culture Media,"[4] as a year has elapsed since the latter was written. For various reasons we are unable to present color standards for the determination of hydrogen ions with the characteristics of simplicity of preparation, of permanence for a reasonable length of time, and of accurate duplication in different laboratories, but our further experiences with the color standards now available may be of interest to laboratory workers and may serve to promote discussion and investigation by others interested in the subject.

MEDALIA'S STANDARDS

As a result of our further work on Medalia's color standards, after the writing of our first paper, we found that we had laid too much stress on these standards and in an unpublished paper on "Quantitative versus Qualitative Adjustment of the H-ion Concentration of Culture Media,"[5] we stated that: "In order to obtain the necessary degree of accuracy for adjusting the reactions of media with alkaline-acid color standards we are convinced, after five months' work, that they must be checked against standards prepared from the buffer mixtures of Clark and Lubs." This constitutes of course a serious objection to these standards because their ease of preparation was offered as a striking advantage over other standards. While we have found that the pairs of standards at either end of the range recom-

[1] Read by title before the Chemical and Bacteriological Section, at the Philadelphia Convention, May 19, 1922.

[2] Physiologist to The Panama Canal. In charge of purification of water supplies on the Canal Zone and of the testing laboratories of the Municipal Engineering Division of The Panama Canal. Ancon, Canal Zone.

[3] Chemist and Bacteriologist at Miraflores Purification Plant, Ancon, Canal Zone.

[4] This Journal, 9: 63–116.

[5] Presented before the Division of Water, Sewage and Sanitation at the 62nd Meeting of the American Chemical Society, New York, N. Y., September 6 to 10, 1921.

mended by Medalia are in error, yet, in checking them against standards prepared from the buffer mixtures of Clark and Lubs, we have not found the error to be as great as that pointed out by Gillespie (1921), that is, nearly pH 0.1 for pairs 2 and 6 and about pH 0.25 for pairs 1 and 7.

Following is a comparison between a set of Medalia's standards and a set prepared from the buffer mixtures of Clark and Lubs:

CLARK AND LUBS BUFFER MIXTURES AND INDICATOR*	MEDALIA'S STANDARDS AND INDICATOR*
pH 6.4	pH 6.4, a shade bluer
pH 6.6	pH 6.6, a shade bluer
pH 6.8	pH 6.8, a shade bluer
pH 7.0	pH 7.0, a shade bluer, nearly pH 0.05 stronger
pH 7.2	pH 7.2, pH 0.05 stronger
pH 7.4	pH 7.4, pH 0.05 stronger
pH 7.6	pH 7.6, pH 0.05 stronger

* Brom thymol blue.

The standards of the same pH value were compared against each other. Medalia's standards were 22 days older than those of Clark and Lubs when the comparison was made, but the former do not change to any appreciable extent in this period of time.

When the same sets of standards were used for determining the H. I. C. of media and water the individual standards did not check so closely as the following examples show:

	CLARK AND LUBS BUFFER MIXTURES AND INDICATORS		MEDALIA'S STANDARDS AND INDICATOR
Lactose broth.....	pH 6.9+*	2 cc. broth and 8 cc. water	pH 6.8+*
Eosine methylene blue agar.....	pH 7.2*	2 cc. agar and 8 cc. water	pH 7.1*
Endo's agar.....	pH 7.9+†	10 cc. agar	pH 7.6+†
	Determination of pH of waters‡		
Raw water.....	pH 7.5*		pH 7.2+*
Aerated water.....	pH 7.7+†		pH 7.4+†
Mixed water.....	pH 6.9*		pH 6.8*
Settled water.....	pH 7.0*		pH 6.8+*
Filtered water.....	pH 7.1+*		pH 7.0*
Chlorinated water	pH 7.0*		pH 6.9*

* Brom thymol blue.

† Phenol red.

‡ Ten cubic centimeters of water used.

A BUFFER MIXTURE OF WIDE RANGE (pH 1 TO 12), BUFFER TABLETS, AND INDICATOR TABLETS

A buffer mixture of wide range, with which a curve is furnished, to show the amount of N/1 or N/5 acid and alkali to be added to a certain volume of the liquid (20 cc.) to obtain a standard of any desired pH value from pH 1 to 12, should be very useful, especially in the smaller laboratories or in those in which only an infrequent determination of hydrogen-ion concentration is made, provided that the mixture will keep without changing for a reasonable length of time and that sufficient care is exercised in its preparation to insure the accuracy of the standards prepared from it. The company supplying the buffer mixture states that every point of the curve for the entire range between pH 1 to 12 has been determined electrometrically and that the mixture will keep indefinitely. The following table gives a comparison of standards made from a buffer mixture of Clark and Lubs, using the same indicator solution with all the standards

STANDARDS FROM CLARK AND LUBS BUFFER MIXTURE		STANDARDS FROM BUFFER MIXTURE OF WIDE RANGE
	Brom thymol blue indicator (0.04 per cent)*	
pH 6.0	.....a shade stronger than.....	pH 6.0
6.2	.....a shade stronger than.....	6.2
6.4	.....a shade stronger than.....	6.4
6.6	.....a shade stronger than.....	6.6
6.8	.....a shade stronger than.....	6.8
7.0	.....0.1 pH stronger than.....	7.0
7.2	.....0.15 pH stronger than.....	7.2
7.4	.....0.20 pH stronger than.....	7.4
7.6	.....0.20 pH stronger than.....	7.6
	Phenol red indicator (0.02 per cent)*	
6.8	.....a shade stronger than.....	6.8
7.0	.....0.05 pH stronger than.....	7.0
7.2	.....0.10 pH stronger than.....	7.2
7.4	.....0.15 pH stronger than.....	7.4
7.6	.....0.20 pH stronger than.....	7.6
7.8	.....0.20 pH stronger than.....	7.8
8.0	.....0.10 pH stronger than.....	8.0

* From Hynson, Westcott and Dunning.

In the case of the B. T. B. standards the colors match closely from pH 6.0 to 6.8 inclusive, but starting with pH 7.0 and going up to pH 7.6 the standards vary by differences of pH 0.1 to 0.2. In the case of the phenol red standards only the lowest one, pH 6.8, matched closely, all of the higher ones, from pH 7.2 to 8.0, varying by differences of pH 0.1 to 0.2. In all cases the C. and L. standards were stronger than those made from the buffer mixture of wide range.

To obtain a comparison in a more practical manner the hydrogen-ion concentrations of six waters and of two media were determined by four sets of color standards.

	STANDARDS PREPARED FROM			
	Buffer mixture of Clark and Lubs*	Buffer mixture of wide range		Buffer tablets with indicator†
		Indicator*	New indicator*	
	(1) *pH*	(2) *pH*	(3) *pH*	(3) *pH*
Raw water	7.3	7.4+	7.5	7.5
Aerated water	7.7	7.8	7.8+	7.8+
Mixed water	7.0	7.0+	7.1	7.2
Settled water	7.1	7.2+	7.1+	7.2
Filtered water	7.2	7.3+	7.4	7.3
Chlorinated water	7.1+	7.3	7.4	7.3
Lactose broth	7.0		7.0+	7.1
Nutrient agar	7.1		7.2	7.2+

* Hynson, Westcott and Dunning's indicator.

† Indicator furnished by Company supplying buffer mixture of wide range.

Note: Brom thymol blue (0.04 per cent) used up to and including pH 7.6; phenol red (0.02 per cent) used above pH 7.6.

As compared with the hydrogen-ion concentrations determined by the standards made from the buffer mixture of Clark and Lubs (column 1), it is seen that the values in column 2, obtained by using standards prepared from the buffer mixture of wide range (pH 1 to 12) agree more closely than the values in column 3, also obtained by using standards prepared from the latter buffer mixture. The standards used for obtaining the values in column 3 were prepared in the same manner as those used for obtaining the values in column 2, but the indicator used with the former was supplied by the company furnishing the buffer mixture of wide range, while the indicator used with the standards of columns 1 and 2 was the same, i.e., from

Hynson, Westcott and Dunning. In comparing the B. T. B. indicator (dry powder) supplied by the company furnishing the buffer mixture of wide range, we found that a 0.04 per cent solution of the latter was weaker than a 0.04 per cent solution of the former although both were prepared in the same manner.[6] The indicator supplied by the latter company did not entirely dissolve even after the required addition of NaOH. The same relation was found to exist with the phenol red indicators (dry powders) supplied by the two companies although in this case both dissolved completely.

While we have not made a comparison of the indicators of the various companies which manufacture them and, therefore, we are not in a position to recommend the products of any one company, we believe it is desirable for those engaged in this work to purchase such an amount of each indicator as will last for a considerable period of time and always to state the name of the manufacturer in publishing the results of their work, because undoubtedly there will be some difference in the strength and quality of the same indicators manufactured by the various companies. We feel that a comparison of the indicators on the market should be made by some disinterested party, even if the comparison is limited to the few most commonly used, such as brom thymol blue, phenol red, and perhaps cresol red (for standards from pH 8.0 to 8.6). In all of our work with standards prepared with brom thymol blue and phenol red we have used indicators furnished by Hynson, Westcott and Dunning, but this does not signify that indicators of other companies are of inferior quality, because we have not been in a position to try them.

Returning to the consideration of the data in columns 1 and 2 of the last table, we find that as the H. I. C. rises above pH 7.0 the values in column 2 are pH 0.1 + (the + sign indicates that the H. I. C. is estimated to be pH 0.05 greater than the figure given) greater than the corresponding values in column 1, the same indicator solution having been used in all cases. Therefore, in the determination of the H. I. C. of a water or medium, which is above pH 7.0, by means of standards prepared from a single buffer mixture of wide range, it appears that the values will be at least pH 0.15 too high with the indicator of one manufacturer and may be from pH 0.1 to 0.25 too high with the indicator of some other manufacturer (column 3). On the other hand, we have no assurance that the indicator of a third manufacturer might not give values too low by the same differences. So once more we are forced to the conclusion that standards pre-

[6] Clark, W. M., The Determination of Hydrogen-Ions, 1920, page 66.

pared from a single buffer mixture of wide range must be checked against standards prepared from the buffer mixtures of Clark and Lubs, which, as we noted in the case of Medalia's standards, constitutes a serious objection to the use of a single buffer mixture.

As to the keeping qualities of standards made from the single buffer mixture of wide range which we have, it is our opinion that standards prepared with B. T. B. in test tubes of Pyrex glass, closed with paraffined cork stoppers, and kept in the dark when not in use, will not remain unchanged for a period of over four weeks: while P. R. standards will not remain unchanged for a period of over three weeks.

To be perfectly fair to all parties concerned we will point out that in all of our work we have assumed that the standards prepared from the buffer mixtures of Clark and Lubs and the indicators prepared according to their directions have been so nearly correct that for all practical purposes they were correct or, in other words, that, if the H. I. C. of a sample of water were found to be pH 7.2 by one of these color standards, the same value would have been obtained by electrometric measurements. The directions given by Clark (1920) for the preparation of the buffer mixtures have been closely followed and great care has been taken both in this respect and in the subsequent preparation of the color standards. We have made no checks by electrometric measurements because we do not have the necessary apparatus.

INDICATOR TABLETS

From one of the commercial laboratories we obtained indicator tablets, one of which may be added to 20 cc. of a solution of which it is desired to determine the H. I. C., instead of adding a measured amount of an indicator solution. Phenol red and brom thymol blue tablets were tried out with the following results.

	AERATED WATER PLUS		FILTERED WATER PLUS	
	P.R. indicator tablet	P.R. indicator solution*	B.T.B. indicator tablet	B.T.B. indicator solution*
	pH	*pH*	*pH*	*pH*
(1) Standards prepared from the buffer mixture of wide range and indicator solution	7.5	7.8	7.4+	7.1+
(2) Standards prepared from buffer tablets and the same indicator used above	7.3+	7.8	7.3+	7.2+

* Same solution as used in (1) and (2).

The H. I. C. of a sample of filtered water to which a B. T. B. indicator tablet was added was found to be pH 7.4 + as compared with pH 7.1 + of a portion of the same water to which a B. T. B. indicator solution was added. No closer check was obtained in determining the H. I. C. of a sample of aerated water. In both of these cases the indicator tablets gave hydrogen-ion concentrations differing by pH 0.3 from those given by the indicator solutions. The standards against which the comparison was made were prepared from the single buffer mixture previously discussed and the indicator solutions used, both with the standards and the samples of water, were prepared from indicators (dry powders) supplied by the company manufacturing the buffer mixture so that the comparisons would be made under the most favorable conditions. The second set of values given in the same table were obtained by using a different set of standards, prepared from buffer tablets (to be discussed later), and it is seen, in the case of the aerated water, to to which the P. R. indicator tablet was added, that the H. I. C. was determined as pH 7.3 or pH 0.4 + lower than a portion of the same water to which a P. R. indicator solution was added. Such results do not allow us to be even favorably inclined to the use of indicator tablets.

A B. T. B. indicator tablet was added to 20 cc. of lactose broth and a comparison was made with the same standards in the above table (1). The H. I. C. was called pH 6.7, but as the shade of color was different from that of the standards an exact match could not be made. The H. I. C. of the same broth to which a B. T. B. indicator solution was added, as compared with the same standards, was found to be pH 7.0+, a difference of pH 0.3+.

A B. T. B. indicator tablet was added to 20 cc. of nutrient agar but before it dissolved the latter had hardened, for it takes about fifteen minutes for an indicator tablet to dissolve in broth or agar. The agar was remelted but the color of the resulting mixture was entirely different from that of the proper color standard.

To obtain some idea as to whether or not there is a variation in the individual indicator tablets, three P. R. tablets and three B. T. B. tablets were added to as many portions of water and the resulting colors compared against standards prepared from the buffer mixtures of Clark and Lubs, with the following results:

	AERATED WATER PLUS A P.R. TABLET	FILTERED WATER PLUS A B.T.B. TABLET
	pH	*pH*
Tablet 1	7.5	7.1
Tablet 2	7.2	7.1
Tablet 3	7.4	7.1+

Therefore in using P. R. indicator tablets it appears that one can only expect to approximate the H. I. C. of a water to within pH 0.3. The three B. T. B. tablets gave results almost equal. However, with both kinds of tablets, colors were obtained which were off shade.

Our experience with the indicator tablets has been very disappointing and we cannot recommend their use for even approximate work, either in a laboratory or in the field.

BUFFER TABLETS

From the same commercial laboratory we obtained buffer tablets, one of which on being dissolved in 20 cc. of distilled water is supposed to give a buffer mixture of the pH value marked on the container. The company supplying them state that they are accurate to ±0.02 pH and will keep indefinitely.

To ascertain the accuracy of the tablets relative to the buffer mixture of wide range put up by the same commercial laboratory, standards of the pH values shown in the following table were compared against each other. The same indicator solutions were used with the four sets of standards.

STANDARDS FROM BUFFER MIXTURE OF WIDE RANGE		STANDARDS FROM BUFFER TABLETS
	Brom thymol blue indicator	
pH 6.4	0.1 pH stronger than	pH 6.4
6.6	0.1 pH stronger than	6.6
6.8	a shade stronger than	6.8
7.0	0.15 stronger than	7.0
7.2	a shade stronger than	7.2
7.4	0.15 pH weaker than	7.4
7.6	0.05 pH stronger than	7.6

STANDARDS FROM BUFFER MIXTURE OF WIDE RANGE		STANDARDS FROM BUFFER TABLETS
	Phenol red indicator	
6.8	.....matches.....	6.8
7.0	.....0.10 pH stronger than.....	7.0
7.2	.....0.05 pH weaker than.....	7.2
7.4	.....nearly 0.2 pH weaker than.....	7.4
7.6	.....0.1 pH weaker than.....	7.6
7.8	.....matches.....	7.8
8.0	.....nearly 0.1 pH stronger than.....	8.0
8.2	.....0.1 pH stronger than.....	8.2

In this same connection the reader is referred back to column 4 of the table under the discussion of the buffer mixture of wide range, which gives a comparison of the hydrogen-ion concentrations of six waters and two media. Comparing the values obtained with the buffer tablet standards (column 4) with those secured with the standards from the buffer mixtures of Clark and Lubs (column 1), we find that the former are from pH 0.1 to pH 0.2 higher than the latter. If a similar comparison is made with the standards of the buffer mixture of wide range (column 3), we find that there is a closer agreement, the maximum difference being pH 0.1.

Our experience with such tablets may be summed up as follows:

1. There is a variation in the strength of individual tablets in a container marked with a certain pH value.

2. The tablets will not always yield solutions of a pH value equal to that marked on the container.

3. Two tablets in a container marked pH 7.0 gave a light red color to the distilled water in which they were dissolved prior to the addition of an indicator.

4. A set of color standards can not be prepared from such tablets without checking them against standards of known value.

5. We can not recommend the use of such tablets for the accurate determination of hydrogen-ion concentrations, but they may be used for approximate determinations.

STANDARDS FROM THE BUFFER MIXTURES OF CLARK AND LUBS

During the last eight months we have used these standards entirely for adjusting the reactions of culture media and for making routine daily determinations of the H. I. C. of samples of water collected at

different points in its travel through each of the three purification plants on the Canal Zone. Our experience with such standards may be summarized as follows:

1. A buffer mixture will remain unchanged for at least four months in a bottle of amber glass, coated on the inside with paraffin, and closed with a perforated rubber stopper carrying an ordinary 10 cc. bacteriological pipette with a glass cap, containing cotton, over the upper end. We have not had occasion to keep a buffer mixture longer than this on account of preparing many sets of standards for three laboratories, but Foster and Randall (1921) state in this respect:

> Check determinations on the mixtures at the outset and after a period of seven months showed that the standard buffers, from bottles in which the paraffin was not broken, had remained constant in pH in spite of the fact that molds had developed in some of the liquids. Sorensen (1909a) reported a similar observation on solutions after nine months standing.

2. Indicator solutions of brom thymol blue and phenol red (prepared according to the directions of Clark) will remain unchanged for at least six months if they are kept in amber colored bottles and in the dark when not in use. For daily service, we use an amber colored bottle, capacity 250 cc., closed with a perforated rubber stopper carrying an ordinary 1 cc. bacteriological pipette. Such a pipette must be carefully cleaned and tested before it is placed in use as otherwise when brom thymol blue, for example, is drawn up into it the color of the indicator will be changed. Two hundred and fifty cubic centimeters of an indicator will last about three months, at the end of which time the bottle is sterilized and refilled from the bottle carrying the stock solution. Five-tenths cubic centimeter of indicator solution is used in each test.

3. Standards with values ranging from pH 5.8 to 8.0 have been prepared from the KH_2PO_4–NaOH buffer mixture, while those with values greater than pH 8.0 have been prepared from the buffer mixtures of boric acid, KCl and NaOH as specified by Clark and Lubs. Test tubes of Pyrex glass (without lips, 125 by 15 mm. outside diameter) have been used as containers and have been stoppered with well paraffined cork stoppers.

4. So far we have been unable to make a set of brom thymol blue standards which will remain unchanged for more than four weeks. We have found them to be very sensitive to light exposure and in order to reduce this action to a minimum while the standards are

out on the bench for use we keep them in a block of wood containing holes of such length that only the cork stoppers in the ends of the tubes project above the top of the block. The phenol red standards will not remain unchanged for more than two weeks.

5. It is only fair to admit, as far as the keeping qualities of the standards are concerned, that those put up by The Hynson, Westcott and Dunning Pharmaceutical Laboratory are far superior to any we have prepared. Whether this superiority is due to the preparation of the standards from acid potassium phosphate and alkaline sodium phosphate with the use of an indicator of different strength we are not prepared to say. If the above mentioned company or some other would put out their standards in test tubes or ampoules measuring 15 mm. in outside diameter, and furnish a comparator block similar to the one shown in figure 6 of our first paper, except that the back row of three holes may be omitted, leaving the plan as shown in figure 4 of the same paper, we are of the opinion that they would be much more useful for water laboratory work.

6. Based on our experience with standards prepared from the buffer mixtures of Clark and Lubs we can not recommend their use in small isolated laboratories unless some arrangement is made to replace them frequently with freshly prepared and standardized sets.

COLOR STANDARDS PREPARED FROM MINERAL COLORS

The following abstract shows that Kolthoff (1921) has done some work along this line:

> For finding pH values a simpler method is explained than by the use of buffer solutions; it consists in comparing the color of 10 cc. of the test water (containing 0.1 cc. of 0.1 per cent of neutral red solution) with 10 cc. of the standard mixture of cobalt nitrate and ferric chloride in the following quantities: 72.8 grams of crystallised cobalt chloride in 1 liter of 1 per cent hydrochloric acid, and 45.05 grams $FeCl_3$, 6 H_2O in 1 liter of 1 per cent hydrochloric acid. The pH value of drinking water is generally between 7.0 and 8.0.

In our unpublished paper, previously referred to, we commented on this as follows:

> As far as we know no work has been done on the development of such standards in the United States, but in a recent private communication from Dr. Frank E. Hale[7] the opinion was expressed that this was the proper line

[7] Director, Mt. Prospect Laboratory, Bureau of Water Supply, Brooklyn, N. Y.

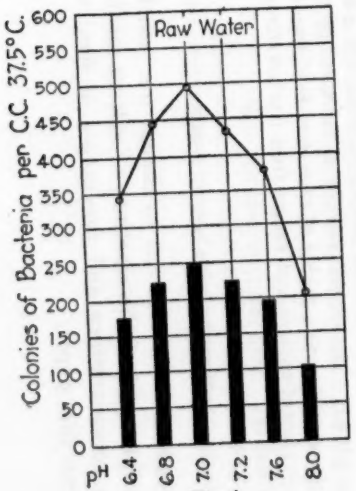

Fig. 1

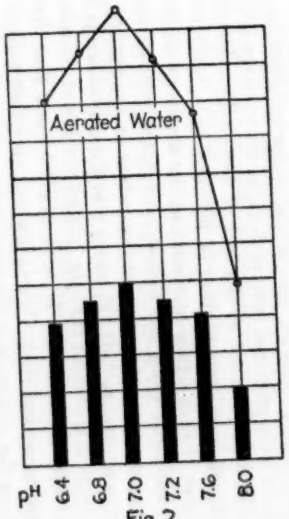

Fig. 2

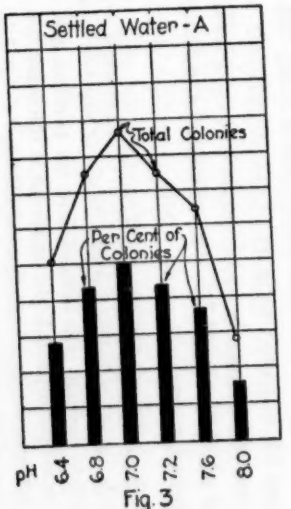

Fig. 3

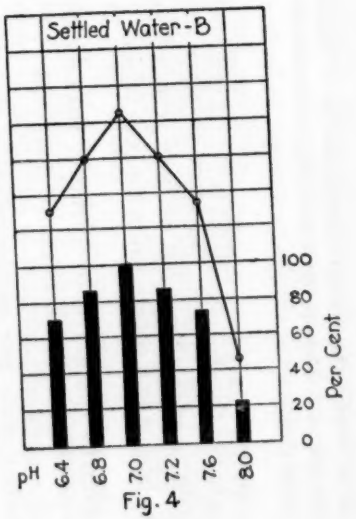

Fig. 4

along which to work. Our recent experiences with alkaline-acid color standards have led us to the same conclusion, and we are now developing a set of mineral color standards.

Unfortunately we have been unable to devote sufficient time to the developnent of mineral color standards to allow us to publish anything definite at this time, but we have resumed work on them and hope to push it to a conclusion in the near future.

THE INFLUENCE OF THE H. I. C. OF NUTRIENT AGAR ON THE DEVELOPMENT OF COLONIES OF BACTERIA

In connection with our recommendation that the reaction of nutrient agar be adjusted to a H. I. C. of pH 7.0 and that the variation from this figure be confined to a range of H. I. C. corresponding to pH 6.8 and pH 7.2, we submitted the following data in our unpublished paper:

> In order to determine the influence of H. I. C., on either side of "true neutrality," pH 7.0, on the development of colonies of bacteria on nutrient agar, one batch of this medium was divided into six portions and starting with the "native" reaction of pH 6.4, the reactions of the other five portions were adjusted to hydrogen-ion concentrations of pH 6.8, 7.0, 7.2, 7.6, and 8.0.
>
> Using samples of raw, aerated, and settled water collected on nine consecutive days, plates were prepared from each of the six portions and the colonies developing at 37.5 C. counted at the end of twenty-four hours. The data obtained in this manner were plotted in figures 1 to 4, inclusive, the curve in the upper part of each figure representing the means of all the counts for each H. I. C. indicated along the bottom, while the vertical bars show the relation of these means to the mean of the counts on the portion of the agar adjusted to "true neutrality" pH 7.0, which is arbitrarily taken as 100 per cent. Thus in each figure it is evident that the largest number of colonies developed on the nutrient agar adjusted to a H. I. C. of pH 7.0 and that the numbers of colonies diminished as the H. I. C. was lowered on either side of "true neutrality," reaching the minimum in the case of the portion of medium adjusted to a H. I. C. of pH 8.0. The general relation as indicated by the plotting of the means of the counts over a period of nine days held true for each set of counts from each class of water, which ranged from 6 to 820 colonies of bacteria per cubic centimeter.

SUMMARY AND CONCLUSIONS

No developments have occurred to change our conclusions concerning the adjustment of the reactions of culture media to definite hydrogen-ion concentrations and the ranges of final reactions as expressed in our first paper.

Further work with Medalia's standards has necessitated a change in our opinion concerning their accuracy and we now believe that they must be checked against standards prepared from the buffer mixtures of Clark and Lubs.

Buffer tablets and indicator tablets now on the market should be used only for obtaining an approximation of the hydrogen-ion concentration of media or waters. The reactions of media should not be adjusted by these tablets.

Color standards for the determination of hydrogen-ions with the characteristics of simplicity of preparation, of permanence for a reasonable length of time, and of accurate duplication in different laboratories, are not yet available.

We wish to take this occasion to urge other workers to publish their experiences with the colorimetric determination of hydrogen-ions, either in water samples or in connection with the adjustment of the reactions of culture media. Short discussions in the JOURNAL of this Association on the papers presented at the Annual Conventions or short contributions in between Conventions are of great value and help to the authors of papers and to those interested in the subject under discussion. We hope that the members of this Association who have been working along the same lines, more or less, will contribute to the discussion of this paper so that all who are interested in the subject and its development may benefit by their experiences. Only in this way can be majority of workers keep in touch with the current developments, assist each other, and reduce the period of time in which the experimental work is carried to a successful conclusion.

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LABORATORY CONTROL OF THE MANUFACTURE OF WATER WORKS PLUMBING AND GAS BRASS GOODS[1]

By W. Everett Mueller[2]

In the water works and plumbing business it is highly desirable to use materials which will give the longest service with the least attention. The greater proportion of the materials used by these two important businesses consist of what are known as ferrous and non-ferrous alloys. It is the non-ferrous products with which this paper will deal.

Everybody realizes that there are literally thousands of different non-ferrous alloys on the market in one form or another, and to tell which alloy is best suited for any particular use is difficult. This choice of alloy has not only been difficult for the engineer but for the manufacturer.

The H. Mueller Manufacturing Company of Decatur, Illinois, has done considerable experimental and control work in their laboratory and it is that work and experience which I will try to give you in a brief way in this paper, with the hope that it may be of service to you in the future purchasing of brass goods.

In the study of metals it is necessary to make tests in different ways, the most important of which are hardness, chemical composition, tensile strength, yield point, percentage of elongation, macroscopic and microscopic examination.

The hardness tests are made usually by one of three methods. The Brinell method consists of pressing a steel ball into the metal and then measuring the depth or width of indentation. In the Rockwell method a small steel ball presses into the metal and the hardness is determined by an automatic indication of the depth the ball penetrates the metal. At present these two methods are considered the most reliable. Figure 1 shows the Brinell hardness tester in the laboratory of the Mueller Company.

The third test is by the scleroscope which is an instrument for dropping a tiny diamond pointed steel hammer on the metal to be

[1] Presented before the North Carolina Section meeting, November 15, 1922.

[2] Of H. Mueller and Company, Decatur, Ill.

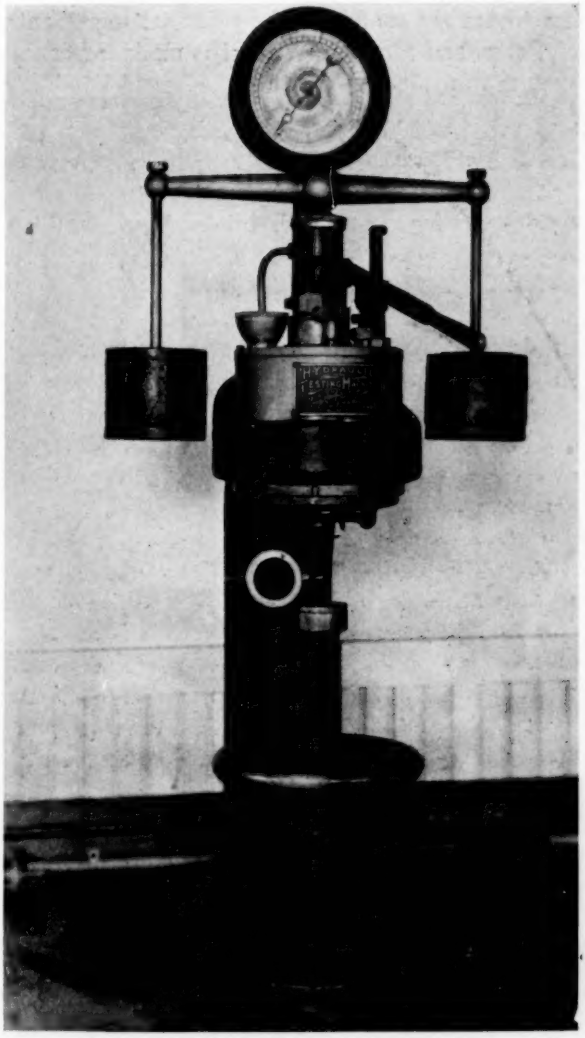

FIG. 1. BRINNELL HARDNESS TESTER

tested and measuring the rebound. The distance of rebound indicates the hardness of the metal. This method however is gradually losing prestige. Figure 2 shows the scleroscope as used in the laboratory.

The chemical composition tests are made by chemical analysis. The usual analyses are made for the principal ingredients, copper tin, lead and zinc, and a qualitative test is made for contaminating elements such as iron, aluminum, etc.

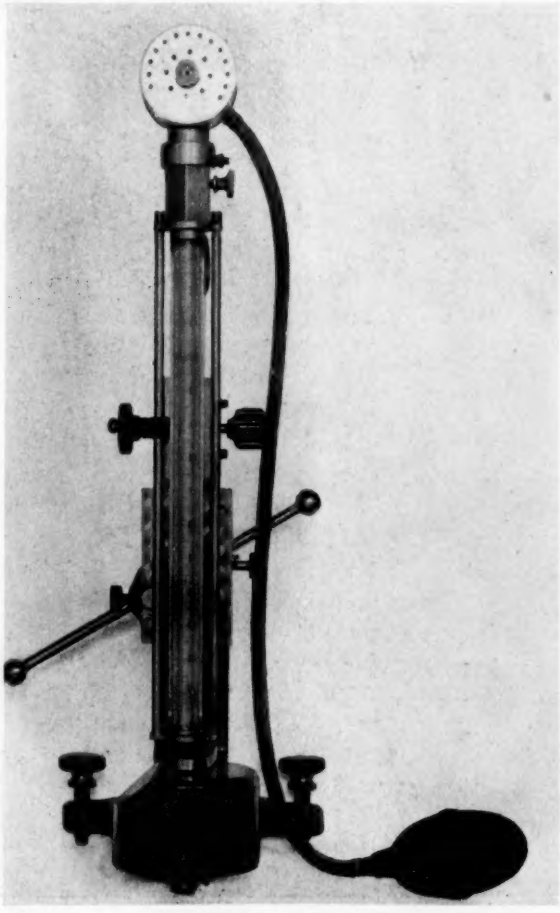

FIG. 2. SCLEROSCOPE

The procedure of this test is to take a sample of the metal and drill from it a number of chips. From this collection of chips, a one gram sample is weighed on an accurate balance. It is then placed in a glass vessel containing nitric acid. To this solution of

the metal by the nitric acid is added a small quantity of water and this solution is put on the stove and brought to a boiling point. This process will show a white precipitate settling down on the

FIG. 3. TESTING LABORATORY

bottom of the glass container. This precipitate is the tin in the form of oxide. By passing this entire liquid through a filter the tin oxide is collected and weighed.

In the remaining solution are placed two electrodes and an electric current is passed between these through the liquid. The copper deposits in pure condition on one electrode and the lead on the other, as an oxide. These electrodes, taken out and weighed, give the copper and lead contents of the metal. The zinc content is obtained by subtracting the total of the copper, tin and lead from 100. To

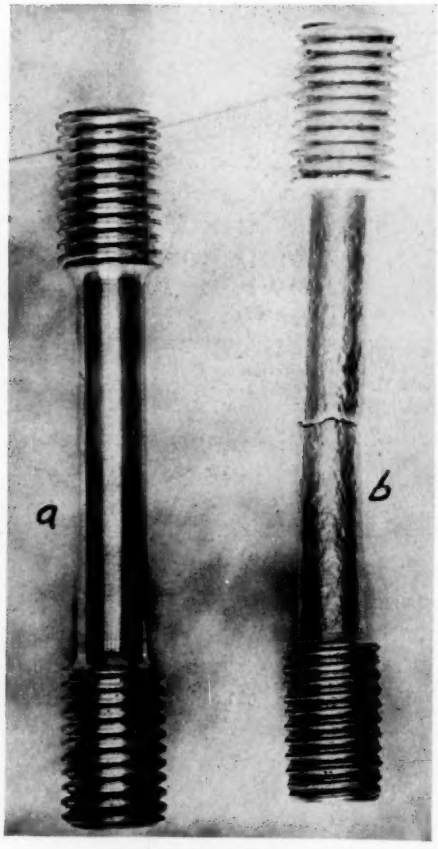

FIG. 4. TEST BARS

the remaining liquid are added certain chemicals which indicate immediately the presence of iron or aluminum. Figure 3 is a view of the testing laboratory.

The percentage of elongation, tensile strength and yield point are obtained from a test bar, shown in figure 4. The test bar (*a*) in

figure 4 is placed in a physical testing machine which grips the bar on each end in steel jaws as shown in figure 5 and indicated by the arrow. These two jaws are moved apart mechanically and the amount of force exerted is measured. In this manner we are able to get the force required to begin stretching the bar and that is called the yield point. We continue with an increased force or

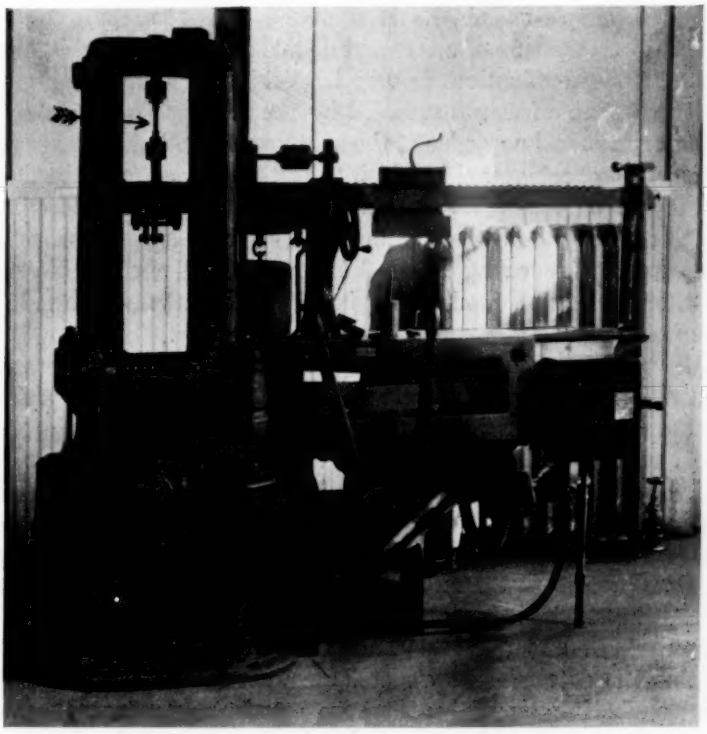

FIG. 5. PHYSICAL TESTING MACHINE

pull until the bar breaks and that force is called the tensile strength. The percentage of elongation is secured by putting the two pieces of the bar back together again as shown in (*b*) figure 4 and with a pair of calipers measuring the increase in length over the original bar.

This test is used by many purchasers as a guide to the quality of the goods they are buying and also as an insurance that the manufacturing processes in the foundry are right. If properly handled it is a quick and positive check on quality of metal.

Macroscopic and microscopic examinations are somewhat similar but different enough to be given separate explanation.

Macroscopic examination is best explained as in a circular published by the Bureau of Standards, as follows: "The study of the structure of any metal must properly begin with the macroscopic examination of the specimen, that is, with an examination which does not involve any magnification other than that obtained by the use of the simple magnifier. It is quite evident that the knowledge of the gross structure of alloys and metals gained by the preliminary macroscopic examinations is very helpful in understanding properly the more minute features revealed by the microscope in exactly the same way that a knowledge of the anatomy of the human body must be used as a background in which to fit the information gained by a study of the histological or minute features of the various tissues which make up the body. Although this survey is usually made for the purpose of revealing chemical unhomogeneity, generally by some suitable etching method, other important structural features are often revealed."

Microscopic examination is the examination by a microscope under high power magnification of a selected area of the specimen. This outline of tests brings us then to the interpretation of these tests, namely of what good are they and how may we use them.

The use and importance of the hardness test is to control the hardness of the metal. The harder a metal is, the slower it must be machined and consequently the higher is the cost of those articles. Obviously, then, if the metal is harder than necessary to stand the work it has to do, it is an unnecessary and additional expense to the manufacturer and ultimate consumer. The necessary and proper hardness is determined by experience with the use of the product. Here again, in order to benefit from experience gained in the use of the product, we must have some definite measures of the characteristics thereof so as to keep a record for future reference and control.

The chemical analysis is used to control the chemical composition of the material so that we may get the same composition each time. After learning by experience and experiment the proper chemical composition, it is an easy matter to maintain that composition, in the future manufactures and thus guarantee to the consumer satisfactory service, or at least give them the benefit of the experience and experiment.

The tensile strength, percentage elongation and yield point are used more for the engineer and designer to supplement chemical

and hardness tests. These properties are of extreme importance when designing the article. For example, curb and corporation cocks are subjected to an internal strain due to the water pressure and a much greater strain due to twisting, when being installed. It is the duty of the designer so to design the goods as to withstand those strains, but unless he knows how many pounds per square inch the metal will stand, he is naturally much handicapped in determining the thickness of the metal and its distribution. On the other hand, if the designer knows exactly what his metal can do and can depend upon the strength of that type of metal, he proportions his article in an accurate way. It becomes important for the purchaser in comparing two articles for the same service, when one is heavier than the other, or vice versa, to make sure of the physical properties of the metals in the two samples. In a comparison of two articles one may be found to have a great deal more metal on it than the other and this is sometimes used as a talking point for the sale of the articles, but it is obvious that, if the strength of the metal in the heavier sample is less than that of the lighter sample, the additional metal is placed on the heavier sample to make it equal the service given by the lighter sample.

The macroscopic and microscopic examinations reveal important structural features of the material, such as the size and shape of the crystals, arrangement of crystal grains, lack of grain refinement, persistence of casting structure, physical unsoundness, as flakes and internal fractures, blow holes, gas cavities, porosity and slag inclusions. One of the most serious and most common of defects, as revealed by this examination, is the lack of chemical homogeneity. This variation of chemical composition generally results in a differential attack of the material when it is subjected to the action of a corrosive agent. All of the defects here mentioned are extremely detrimental in those parts of a water pipe which are to be buried under ground, as none of these may appear until the article has been in service for a few months. For example, slag inclusions usually occur in the thinnest section of the article and may constitute 90 per cent of the cross sectional area at that point, which does not show on initial visual examination because it has been covered over with a thin skin of metal which is invariable strained when a cock is installed and the result is a leak which will grow larger and larger until it is as much as $\frac{1}{4}$ inch in diameter after a few weeks.

The hidden defects are practically all brought out by the macroscopic and microscopic examinations. These are serious defects and practically every one of them may be prevented by proper foundry practice in manufacturing. In order that good foundry practice may be maintained it is necessary that it be controlled by laboratory tests. Besides using these tests, proper records must be made and information collected to be used intelligently for the betterment of the product.

To give you an idea of the necessity of laboratory control there was examined in this laboratory 50 corporation and curb cocks made by the different manufacturers in the United States. Of these 50 samples, 45 showed practically all the defects mentioned under macroscopic and microscopic analysis. Four showed slag inclusions and only one showed good foundry practice. Besides these defects as shown by the microscope, the hardness and other tests showed a wide discrepancy. The chemical analyses, however, varied more than any of the others. In several instances, when examining more than one sample from each company, it was noticed that there was a considerable variation in properties between two or more samples of the same make. The point I wish to make here is that a definite metal mixture, strength and hardness must be correct and we ought to find these conditions and hold them.

Laboratory control should not apply only to the foundry and metals, but should extend throughout the entire factory. All purchased materials should be tested before acceptance and manufacturing processes should be checked from time to time.

PROGRESS REPORT OF THE COMMITTEE ON STANDARD FORM OF CONTRACT[1]

During the past year your Committee has taken an active part in the work of the Joint Conference on Standard Construction Contracts, which, as reported last year, consists of representatives of the American Water Works Association, American Society of Civil Engineers, American Institute of Architects, American Association of State Highway Officials, American Railway Engineering Association, Federated American Engineering Societies, Western Society of Engineers, Associated General Contractors of American and National Association of Builders Exchanges. The Joint Conference has endeavored to ascertain from several hundred representative contract forms all those subjects or topics which are common to practically all construction contracts. The various wordings used for each of these subjects were studied and eventually a phrasing was provisionally adopted.

Discussion showed that for a large amount of small construction work for private parties, when the owner and contractor are well acquainted, the contract form actually used is generally short. To meet this condition, the Joint Conference has proposed tentatively a Universal Contract Agreement.

For larger work and for public work in general, the Joint Conference proposes supplementary clauses forming a set of Universal General Conditions. These two documents contain all the clauses which are common today to practically all construction contracts for work of medium and large size. The provisional form of these two documents is printed at the close of this report.

These two documents provide for the arbitration of disputes involving the elements of time and financial affairs; in all other disputes the contract makes the engineer's decision final. Arbitration does not take the place of legal proceedings but is a condition precedent to them, under a contract of this form. All members of your Committee favor arbitration between private parties, but one member questions its desirability in settling disputes over contracts for public work.

[1] Presented before the Detroit Convention, May 22, 1923.

By eliminating the few references to arbitration in the documents submitted herewith, they become suitable for use when no provision for arbitration is desired.

Your Committee expects to suggest a number of changes in these documents at the next meeting of the Joint Conference, intended to bring them into closer harmony with water works practice. Nevertheless your Committee believes that the documents, in their present form, will prove decidedly helpful as a basis on which to draft a contract for any kind of construction, provided the following facts are kept in mind:

1. The periods of time mentioned in some clauses are averages of present custom in all branches of construction, and have been stated as guides merely. The Joint Conference believed it would be more helpful to state these averages than to leave blanks.

2. In many instances the dates of beginning and completing work and stipulations for liquidated damages are important. Article 2 of the Universal Agreement should be filled out to cover them. The Joint Conference has discussed the wording of a stipulation for liquidated damages but reached no decision.

3. The two documents are offered as divisible units. In some contracts for public works it is customary to bind together in one pamphlet the following parts: the Advertisement, published under legal rules in some States; the Instructions to Bidders, requiring the bidder to familiarize himself with the working conditions before bidding and stating the terms of payment; the Form of Bid, usually containing unit prices or the lump sum price, and the time for completion of the work; the Specifications; the Form of Contract, and the Bond.

Where this practice is followed, the documents submitted herewith should be subdivided among the parts of the pamphlet to which they relate.

4. The Joint Conference has not yet proposed forms containing the provisions for bonds and sureties required on public work. These provisions must be carefully considered in any actual contract documents. The Joint Conference has recommended a different clause for bonding railway contractors from that recommended for building contractors.

5. Many of the terms used are subject to change, as "owner" to "city" or "company" and "progress payments" to "estimates." The printed terms are those in most common use, so far as the Joint Conference can ascertain the facts.

These two documents are appended.

Your Committee requests the Association to approve these documents tentatively as a basis on which to develop contracts for water works construction, with the understanding that they are subject to modification to meet local laws and conditions, and must be supplemented in some cases by other clauses, some of which your Committee hopes to offer later.

Your Committee asks to be continued.

Respectfully submitted,

J. WALDO SMITH, *Chairman*,
THEODORE A. LEISEN,
JOHN N. CHESTER,
HENRY P. BOHMANN,
CHAS. R. GOW,
CARLETON E. DAVIS,
THOMAS H. WIGGIN,
G. A. ELLIOTT,
JOHN M. GOODELL, *Secretary*.

UNIVERSAL FORM OF AGREEMENT

This Agreement made the.....
day of.....in the year Nineteen Hundred and.....
by and between.....
hereinafter called the Contractor, and.....
hereinafter called the Owner.....
Witnesseth, that the Contractor and the Owner for the considerations hereinafter named agree as follows:

Article 1. Scope of the Work—The Contractor shall furnish all of the materials and perform all of the work shown on the Drawings and described in the Specifications entitled

.....

(Here insert the caption descriptive of the work as used on the Drawings and in the other Contract Documents)

prepared by.....
acting as, and in these Contract Documents entitled the Engineer; and shall do everything required by this Agreement, the General Conditions and Special Conditions of the Contract, the Specifications and the Drawings.

Article 2. Time of Completion—The work to be performed under this Contract shall be substantially completed.....

.....

(Here insert the date or dates of completion, commencement if desired, and stipulation as to liquidated damages, if any.)

Article 3. The Contract Sum—The Owner shall pay the Contractor for the performance of the Contract, subject to additions and deductions provided therein, a sum of money as follows:.....

.....

(State here the lump sum amount, unit prices, or both, as desired in individual cases.)

Where the quantities originally contemplated are so changed that application of the agreed unit price to the quantity of work performed is shown to create a hardship to the Owner or the Contractor, there shall be an equitable adjustment of the Contract to prevent such hardship.

Article 4. Progress Payments—The Owner shall make payments on account of the Contract as provided therein, as follows:

On or about the.....day of each month.....per cent of the value, proportionate to the amount of the Contract, of labor and materials incorporated in the work and of materials suitably stored at the site thereof up to the first day of that month, as estimated by the Engineer, less the aggregate of previous payments; and upon substantial completion of the entire work, a sum sufficient to increase the total payments to.....per cent of the contract price.....

.....

(Insert here any provision made for limiting or reducing the amount retained after the work reaches a certain stage of completion.)

Article 5. Acceptance and Final Payment—Final payment shall be due .....days after substantial completion of the work provided the work be then fully completed and the Contract fully performed.

Upon receipt of written notice that the work is ready for final inspection and acceptance, the Engineer shall promptly make such inspection, and when he finds the work acceptable under the Contract and the Contract fully performed he shall promptly issue a final certificate, over his own signature, stating that the work provided for in this Contract has been completed and is accepted by him under the terms and conditions thereof, and that the entire balance found to be due the Contractor, and noted in said final certificate, is due and payable.

Before issuance of final certificate the Contractor shall submit evidence satisfactory to the Engineer that all payrolls, material bills, and other indebtedness connected with the work have been paid. If after the work has been substantially completed, full completion thereof is materially delayed through no fault of the Contractor, and the Engineer so certifies, the Owner shall, upon certificate of the Engineer, and without terminating the Contract, make payment of the balance due for that portion of the work fully completed. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of claims.

Article 6. The Contract Documents—The General and Special Conditions of the Contract, the Specifications and the Drawings, together with this Agreement, form the Contract, and they are as fully a part of the Contract

as if hereto attached or herein repeated. The following is an enumeration of the Specifications and Drawings:

.....

The Contractor and the Owner for themselves, their successors, executors, administrators and assigns, hereby agree to the full performance of the covenants herein contained.

In Witness Whereof they have executed this Agreement, the day and year first above written.

Universal General Conditions

Article I. The Engineer's Decisions.—The Engineer shall, within a reasonable time, make decisions on all claims of the Contractor and on all other matters relating to the execution and progress of the work or the interpretation of the Contract Documents.

All such decisions of the Engineer shall be final except as to the element of time and the financial considerations involved, which, if no agreement in regard thereto is reached, shall be subject to arbitration.

Art. II. Inspection of Work.—The Owner, the Engineer and their representatives shall at all times have access to the work wherever it is in preparation or progress and the Contractor shall provide proper facilities for such access and for inspection.

If the specifications, the Engineer's instructions, laws, ordinances or any public authority require any work to be specially tested or approved, the Contractor shall give the Engineer timely notice of its readiness for inspection, and if the inspection is by another authority than the Engineer, of the date fixed for such inspection. Inspections by the Engineer shall be promptly made, and where practicable at the source of supply. If any work should be covered up without approval or consent of the Engineer it must, if required by the Engineer, be uncovered for examination at the Contractor's expense.

Re-examination of questioned work may be ordered by the Engineer. If such work be found in accordance with the contract, the Owner shall pay the cost of re-examination and replacement. If such work be found not in accordance with the contract, the Contractor shall pay such cost, unless he shall show that the defect in the work was caused by another Contractor, and in that event the Owner shall pay such cost.

Art. III. Correction of Work Before Final Payment.—The Contractor shall promptly remove from the premises all materials condemned by the Engineer as failing to conform to the Contract, whether incorporated in the work or not, and the Contractor shall promptly replace and re-execute his own work in accordance with the Contract and without expense to the Company and shall bear the expense of making good all work of other contractors destroyed or damaged by such removal or replacement.

If the Contractor does not remove such condemned work and materials within a reasonable time, fixed by written notice, the Owner may remove them and may store the material at the expense of the Contractor. If the Contractor does not pay the expense of such removal within a reasonable time thereafter, the Owner may, upon ten days written notice, sell such materials

at auction or at private sale and shall account for the net proceeds thereof after deducting all the costs and expenses that should have been borne by the Contractor.

Art. IV. Deductions for Uncorrected Work.—If the Engineer deems it inexpedient to correct work injured or done not in accordance with the Contract, the difference in value together with a fair allowance for damage shall be deducted.

Art. V. Protection of Work and Property.—The Contractor shall continuously maintain adequate protection of all his work from damage and shall protect the Owner's property from injury arising in connection with this Contract. He shall make good any such damage or injury, except such as may be directly due to errors in the Contract Documents or caused by agents or employes of the Owner. He shall adequately protect adjacent property as provided by law and the Contract Documents. He shall provide and maintain all passage ways, guard fences, lights and other facilities for protection required by public authority or local conditions.

In an emergency affecting life or the safety of the work or of adjoining property, the Contractor, without special instruction or authorization from the Engineer, is hereby permitted to act, at his discretion, to prevent such threatened loss or injury and he shall so act, without appeal, if so instructed or authorized. Any compensation, claimed by the Contractor on account of emergency work, shall be determined by agreement or arbitration.

Art. VI. Changes in the Work.—The Owner, without invalidating the Contract, may order extra work or make changes by altering, adding to or deducting from the work, the Contract Sum being adjusted accordingly. All such work shall be executed under the conditions of the original contract except that any claim for extension of time caused thereby shall be adjusted at the time of ordering such change.

In giving instructions, the Engineer shall have authority to make minor changes in the work not involving extra cost, and not inconsistent with the purposes of the work, but otherwise, except in an emergency endangering life or property, no extra work or change shall be made unless in pursuance of a written order by the Engineer, and no claim for an addition to the contract sum shall be valid unless so ordered.

The value of any such extra work or change shall be determined in one or more of the following ways:

(a) By estimate and acceptance in a lump sum.

(b) By unit prices named in the contract or subsequently agreed upon.

(c) By cost and percentage or by cost and a fixed fee.

(d) If none of the above methods is agreed upon, the Contractor, provided he receives an order as above, shall proceed with the work, no appeal to arbitration being allowed from such order to proceed.

In cases (c) and (d), the Contractor shall keep and present in such form as the Engineer may direct, a correct account of the net cost of labor and materials, together with vouchers. In any case, the Engineer shall certify to the amount due to the Contractor. Pending final determination of value, payments on account of changes shall be made on the Engineer's estimate.

Art. VII. Claims for Extra Cost.—If the Contractor claims that any instructions by Drawings or otherwise involve extra cost under this contract, he shall give the Engineer written notice thereof before proceeding to execute the work, except in emergency endangering life or property, and, in any event, within two weeks of receiving such instructions, and the procedure shall then be as provided for changes in the work. No such claim shall be valid unless so made.

Art. VIII. Payments Withheld.—The Engineer may withhold or, on account of subsequently discovered evidence, nullify the whole or a part of any estimate to such extent as may be necessary to protect the Owner from loss on account of:

(a) Defective work not remedied.

(b) Claims filed or reasonable evidence indicating probable filing of claims.

(c) Failure of the Contractor to make payments properly to subcontractors or for material or labor.

(d) A reasonable doubt that the contract can be completed for the balance then unpaid.

(e) Damage to another Contractor.

When the above grounds are removed payment shall be made for amounts withheld because of them.

Art. IX. Delays and Extension of Time.—If the Contractor be delayed in the completion of the work by any act or neglect of the Owner or the Engineer or of any employe of either, or by any other Contractor employed by the Owner, or by changes ordered in the work, or by strikes, lockouts, fire, unusual delay by common carriers, unavoidable casualties or any causes beyond the Contractor's control, or by delay authorized by the Engineer pending arbitration, or by any cause which the Engineer shall decide to justify the delay, then the time of completion shall be extended for such reasonable time as the Engineer may decide will compensate for such delay.

No such extension shall be made for delay occurring more than seven days before claim therefor is made in writing to the Engineer. In the case of a continuing cause of delay, only one claim is necessary.

If no schedule or agreement stating the dates upon which drawings shall be furnished is made, then no claim for delay shall be allowed on account of failure to furnish drawings until two weeks after demand for such drawings and not then unless such claim be reasonable.

This article does not exclude the recovery of damages for delay by either party under other provisions in the contract documents.

Art. X. The Owner's Right to Do Work.—If the Contractor should neglect to prosecute the work properly or fail to perform any provision of this contract, the Owner after three days' written notice to the Contractor may, without prejudice to any other remedy it may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor.

Art. XI. Owner's Right to Terminate Contract.—If the Contractor should be adjudged a bankrupt, or if he should make a general assignment for the benefit of his creditors, or if a receiver should be appointed on account of his insolvency, or if he should persistently or repeatedly refuse or should fail, except in cases for which extension of time is provided, to supply enough

properly skilled workmen or proper materials, or if he should fail to make prompt payment to subcontractors or for material or labor, or persistently disregard laws, ordinances or the instructions of the Engineer, or otherwise be guilty of a substantial violation of any provision of the contract, then the Owner, upon the certificate of the Engineer that sufficient cause exists to justify such action, may, without prejudice to any other right or remedy and after giving the Contractor seven days' written notice, terminate the employment of the Contractor and take possession of the premises and of all materials, tools and appliances thereon and finish the work by whatever method he may deem expedient. In such case the Contractor shall not be entitled to receive any further payment until the work is finished. If the unpaid balance of the contract price shall exceed the expense of finishing the work, including compensation for additional managerial and administrative services, such excess shall be paid to the Contractor. If such expense shall exceed such unpaid balance, the Contractor shall pay the difference to the Owner. The expense incurred by the Owner as herein provided, and the damage incurred through the Contractor's default, shall be certified by the Engineer.

Art. XII. Right to Stop Work or Terminate Contract.—If the work should be stopped under an order of any court, or other public authority, for a period of three months, through no act of fault of the Contractor or of any one employed by him, or if the Engineer should fail to issue any estimate for payment within seven days after it is due, or if the Owner should fail to pay to the Contractor within seven days of its maturity and presentation, any sum certified by the Engineer or awarded by arbitrators, then the Contractor may, upon three days' written notice to the Owner and the Engineer, stop work or terminate this contract and recover from the Owner payment for all work executed and any loss sustained upon any plant or materials and reasonable profit and damages.

Art. XIII. Damages.—If either party to this contract should suffer damage in any manner because of any wrongful act or neglect of the other party or any one employed by him, then he shall be reimbursed by the other party for such damage.

Claims under this clause shall be made in writing to the party liable within a reasonable time of the first observance of such damage and not later than the time of final payment, except as expressly stipulated otherwise in the case of faulty work or materials, and shall be adjusted by agreement or arbitration.

Art. XIV. Assignment.—Neither party to the Contract shall assign the Contract or sublet it as a whole without the written consent of the other, nor shall the Contractor assign any moneys due or to become due to him hereunder, without the previous written consent of the Engineer.

Art. XV. Liability Insurance.—The Contractor shall maintain such insurance as will protect him from claims under workmen's compensation acts and from any other claims for damages for personal injury, including death, which may arise from operations under this Contract, whether such operations be by himself or by any subcontractor or anyone directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Engineer, if he so require, and shall be subject to his approval for adequacy of protection.

Art. XVI. Liens.—Neither the final payment nor any part of the retained percentage shall become due until the Contractor, if required, shall deliver to the Owner a complete release of all liens arising out of this Contract, or receipts in full in lieu thereof and, if required in either case, an affidavit that so far as he has knowledge or information the releases and receipts include all the labor and material for which a lien could be filed; but the Contractor may, if any subcontractor refuses to furnish a release or receipt in full, furnish a bond satisfactory to the Engineer, to indemnify the Owner against any lien. If any lien remain unsatisfied after all payments are made the Contractor shall refund to the Owner all moneys that the latter may be compelled to pay in discharging such a lien, including all costs and a reasonable attorney's fee.

Art. XVII. Permits and Regulations.—The Owner shall obtain and pay for all surveys, permits, licenses and permanent easements necessary to give the right to perform the contract. Permits and licenses of a temporary nature necessary for prosecution of the work shall be obtained and paid for by the Contractor.

The Contractor shall give all notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the work as drawn and specified. If the Contractor observes that the drawings and specifications are at variance therewith, he shall promptly notify the Engineer in writing, and any necessary changes shall be adjusted as provided in the Contract for changes in the work. If the Contractor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Engineer, he shall bear all costs arising therefrom.

Art. XVIII. Royalties and Patents.—The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Owner harmless from loss on account thereof, except that the Owner shall be responsible for all such loss when the product of a particular manufacturer or manufacturers is specified but if the Contractor has information that the article specified is an infringement of a patent he shall be responsible for such loss unless he promptly gives such information to the Engineer.

Art. XIX. Superintendence: Supervision.—The Contractor shall keep on his work, during its progress, a competent superintendent and any necessary assistants, all satisfactory to the Engineer. The superintendent shall not be changed except with the consent of the Engineer unless the superintendent proves to be unsatisfactory to the Contractor and ceases to be in his employ. The superintendent shall represent the Contractor in his absence and all directions given to him shall be as binding as if given to the Contractor. Important directions shall be confirmed in writing to the Contractor. Other directions shall be so confirmed on written request in each case.

The Contractor shall give efficient supervision to the work using his best skill and attention. He shall carefully study and compare all drawings, specifications and other instructions and shall at once report to the Engineer any error, inconsistency or omission which he may discover.

Art. XX. Arbitration.—All questions subject to arbitration under this contract shall be submitted to arbitration at the choice of either party to the dispute.

The Contractor shall not cause a delay of the work during any arbitration proceedings, except by agreement with the Engineer.

The demand for arbitration shall be filed in writing with the Engineer, in the case of an appeal from his decision, within ten days of its receipt and in any other case within a reasonable time after eause thereof and in no case later than the time of final payment except as otherwise expressly stipulated in the Contract. If the Engineer fails to make a decision within a reasonable time, an appeal to arbitration may be taken as if his decision had been rendered against the party appealing.

No one shall be nominated or act as an arbitrator who is in any way financially interested in this Contract or in the business affairs of either the Owner, Engineer or Contractor.

The general procedure shall conform to the laws of the State in which the work is to be done. Unless otherwise provided by such laws, the parties may agree upon one arbitrator; otherwise there shall be three, one named in writing, by each party to this Contract, to the other party and the third chosen by these two arbitrators, or if they fail to select a third within the ten days, then he shall be chosen by the presiding officer of the Bar Association nearest to the location of the work. Should the party demanding arbitration fail to name an arbitrator within ten days of his demand, his right to arbitration shall lapse. Should the other party fail to choose an arbitrator within said ten days, then such presiding officer shall appoint such arbitrator. Should either party refuse or neglect to supply the arbitrators with any papers or information demanded in writing, the arbitrators are empowered by both parties to proceed ex parte.

The arbitrators shall act with promptness. If there be one arbitrator his decision shall be binding; if three the decision of any two shall be binding. Such decision shall be a condition precedent to any right of legal action, and wherever permitted by law it may be filed in Court to carry it into effect.

The arbitrators, if they deem that the case demands it, are authorized to award to the party whose contention is sustained such sums as they shall deem proper for the time, expense and trouble incident to the appeal and, if the appeal was taken without reasonable cause, damages for delay. The arbitrators shall fix their own compensation, unless otherwise provided by agreement, and shall assess the costs and charges of the arbitration upon either or both parties.

The award of the arbitrators must be in writing and, if in writing, it shall not be open to objection on account of the form of the proceeding or the award, unless otherwise provided by the laws of the State in which the work is to be performed.

In the event of such laws providing on any matter covered by this article otherwise than as hereinbefore specified, the method of procedure throughout and the legal effect of the award shall be wholly in accordance with the said State laws, it being intended hereby to lay down a principle of action to be followed, leaving its local application to be adapted to the legal requirements of the place in which the work is to be done.

Art. XXI. Execution, Correlation and Intent of Documents.—The Contract Documents shall be signed in duplicate by the Owner and Contractor. In case of failure to sign the General Conditions, Drawings or Specifications, the Engineer shall identify them.

The Contract Documents are complementary, and what is called for by any one shall be as binding as if called for by all. The intention of the documents is to include all labor and materials, equipment and transportation reasonably necessary for the proper execution of the work. It is not intended, however, that materials or work not covered by or properly inferable from any heading, branch, class or trade of the specifications shall be supplied unless distinctly so noted on the drawings. Materials or work described in words which so applied have a well-known technical or trade meaning shall be held to refer to such recognized standards.

ANNUAL REPORT OF THE PUBLICATION COMMITTEE[1]

The work of the Publication Committee comprises formulation of the program for the annual convention and consideration of various questions pertaining to publication of the JOURNAL. This report will discuss these matters in the order named.

Consonant with the expression of opinion from the floor at the Philadelphia Convention, a program lasting through Friday has been arranged. With the superintendents and the Chemical and Bacteriological Section demanding so much time, and the assignment of a whole day to the Standardization Council's committee reports, papers read before the general membership would have otherwise occupied a brief schedule indeed. Based upon the experience of last year and this, it is probably safe to say that the policy of holding a long convention has become fairly well established.

The Committee has endeavored, in a number of sessions, to group topics of a similar nature or of special interest to a part of the membership, in order that those not particularly interested in any session might find time for other matters. It is believed that this course may be preferable to that pursued last year, when dissimilar subjects were included in a single session, in an effort to sustain attention and stimulate interest. At any rate, this method, in relation to the reports of the Standardization Council's committees, has allowed an extra session for both the superintendents and the Chemical and Bacteriological Section. The Publication Committee unfortunately sees no way, however, to accommodate those members who would like to attend the meetings of the superintendents and also those of the Chemical and Bacteriological Section.

A feature of this year's program is the more intensive development of the so-called superintendents' meetings. Various topics are to be introduced by papers and leaders will be available for promoting discussion. The Publication Committee is sincerely appreciative of the efforts of the collaborating committee which has arranged most of this section of the program. While the experiment apparently has culminated successfully in this instance, it may be in order to

[1] Presented before the Detroit Convention, May 22, 1923.

suggest that division of authority or effort courts disaster. The Committee believes that confusion would be eliminated and the chance of error minimized if arrangement of the technical features of the program were centralized. With its own membership representative of the several groups, such as superintendents, chemists and engineers, a Publication Committee could function most smoothly. It could be effectively aided, however, in the arrangement and conduct of the superintendents' sessions, through a subordinate committee of its own appointment. This thought is referred to the Executive Committee for consideration.

In the preparation of the JOURNAL, a number of interesting questions have arisen which demand prompt discussion from the members of the Association. As in every other official journal, the problem of distribution of subject matter becomes each year increasingly troublesome. The Publication Committee, in its report for 1922, endeavored to determine broadly the complexion of the membership distribution in the Association. This attempt was made in order to indicate the probable fields in which the various members would be interested. The Committee offers, in the following summary, an approximate classification of the contributions that have been published in the JOURNAL during the past five years. It is obvious that during this period a fairly equitable distribution of subject matter has resulted, even though probably without rigid intent.

Classification of papers contributed

CLASS	NUMBER SUBMITTED						PERCENTAGE
	1918	1919	1920	1921	1922	Total	
State or civic	1	3	11	2	3	20	5.3
Finance, management	3	10	12	9	4	38	10.1
Contracts, accounts	4	3	1	0	3	11	2.9
Sources of supply	6	9	15	10	8	48	12.8
Pumping	5	5	8	2	1	21	5.6
Pollution, purification	9	19	19	12	23	82	21.9
Distribution	12	12	39	17	26	106	28.3
Laboratory	7	4	14	11	13	49	13.1
Totals	47	65	119	63	81	375	100.0

It is appropriate to state that contributions from operating men have not yet reached the number which the nature of their activities

should call forth. The Committee emphasizes the importance of this branch of the membership responding in an increasing degree to the requests for brief practical papers on the maintenance and operation of water works systems.

The Executive Committee has asked the Publication Committee to report upon the advisability of issuing a decennial index to the proceedings of the Association. Except that of cost, no obstacle is seen to the preparation of such a volume, and authorization on the part of the Executive Committee for negotiation with proper persons to carry out this task is strongly recommended. It is hardly necessary to state that the preparation of a decennial index must be carried out with additional funds and by persons not now engaged by the Association. The material included, however, should be subject to review by the Editor and to control by the Publication Committee.

During the past fiscal year approximately 83 printed pages of abstracts have appeared in the JOURNAL. These abstracts have been met with varying comments on the part of members of the Association. Some have felt that they are too short for adequate service, others that the expense involved does not justify inclusion of so wide a field nor so great space to individual abstracts. The Committee has no method of arriving at an understanding of the wishes of the membership except by requesting discussion at the time of presentation of this report.

In a similar manner, various expressions of feeling resulted upon the issuance of an elaborate index of the abstracts.

The Committee believes that, with careful elimination of unnecessary verbiage, the abstracts section might be advantageously allotted approximately 20 pages per issue and that the annual index should be continued in order that the material may be made available for convenient reference at any time.

It is obvious that, with extension of the abstracts section and with a continually rising quantity of original material presented at the convention and submitted at other times during the fiscal year, the existing budget for publication is inadequate. During the past year the cost of publication of the JOURNAL and the membership supplement was approximately $8,800. It is estimated that the increase of the abstracts section, to the extent above mentioned, will cost about $600. The Committee requests, therefore, that a budget of $9,500 be allowed for the next fiscal year for the publication of the JOURNAL. In this figure there is no considerable allowance for print-

ing a larger volume of original contributions, unless the membership decides against much further development of the abstracts. If sufficient funds were available, it would be desirable, unquestionably, to extend the sphere of the JOURNAL so as to include an increasing number of special contributions not previously presented at the meetings of the Association and its sections. It would be profitable to expend an annual budget of $10,000 on JOURNAL publication if the membership so desired.

The Committee earnestly hopes that definite and frank expressions of opinion will be presented by many members, at the annual meeting, on the various questions which have been raised in this report.

During the year, competitive bids were requested from a number of publishers for printing the JOURNAL. Our present publishers were awarded the work, since their bid was lowest.

Respectfully presented,

ROBERT B. MORSE, *Chairman*,
MALCOLM PIRNIE,
G. H. FENKELL,
H. E. JORDAN,
ABEL WOLMAN, *Editor*.

DISCUSSIONS

This paper,[1] as well as the previous one, contains data that are helpful to all of us. For the past year the writer has been making routine tests for pH values both on the waters at the Highland Park Filtration Plant and on the media used in the Laboratory. There seems little doubt that culture media should be adjusted to a definite pH, by the use of color standards. My experience with methods confirms that of Bunker's: i.e., use Clark and Lub's Buffers if possible; steer clear of Medalia's method, for it is built on false assumptions and is incorrect; the Universal buffer solution reads low; and indicator salts can not be relied on to be of constant strength. I think mineral color standards will not be useful until the purchased indicator powders all give a constant color when made up in the same way. Color standards made from buffer solutions may be kept permanent for four or more weeks by adding three drops of toluene and stoppering with paraffined corks. They should be kept in the dark when not in use. Gillespie's method "without buffers" is accurate and adaptable to the small laboratory. The data which Bunker gives on the pH and the agar count are most convincing.

WILLIAM D. HATFIELD.[2]

CORROSION

In reading Mr. Baylis' criticism[3] of the papers by Wilson and Speller and Kendall there are two impressions which we think ought to be corrected.

Protective coatings were not ignored in the second article, since the range of pH of the water used (Pittsburgh city water of about pH = 6.4) is not that in which protective coatings are formed. No protective coat that offered any serious interference with corrosion was found in any of the velocity determinations. Wilson has pointed out that the boundaries of the pH values within which corrosion is directly proportional to oxygen concentration have not been clearly defined but are approximately in the range of pH 5.0 to 11.0

[1] This Journal, page 672.
[2] Superintendent of Filtration, Highland Park, Mich.
[3] Journal, May, 1923, page 385.

It is also incorrect to assume that, since the water is clear, corrosion is not proceeding. This reasoning ignores pitting or local corrosion which may occur at breaks in the protective scale and which will determine the life of the pipe. The actual amount of iron dissolved may not be enough to discolor the water perceptibly, but the depth of pitting may be considerable, but probably less than with untreated water.

The absence of ferric oxide in the water simply indicates that any colloidal iron formed in the process of corrosion is precipitated on the inside of the pipe and is not readily removed by the motion of the water. It does not form as a dense protective scale, such as is formed by alkaline sodium silicate, but as a more or less voluminous, fairly hard scale in the form of carbuncles. This is quite commonly found in the case of hot water pipes. The analysis of the water for dissolved oxygen shows that oxygen is still being removed by the pipe, and the oxide is not precipitated loosely in the water, but adheres to the inside of the pipe. Our experiments show that, to reduce corrosion to a minimum, hydrate alkalinity from 150 to 350 p.p.m. is necessary. An hydrate alkalinity of 10 to 20 p.p.m. is all that is necessary to produce clear water. The actual amount of alkalinity necessary to inhibit corrosion is dependent to some degree upon the character of water used. It is to be understood, of course, that, due to the buffering effect of other salts present, pH does not necessarily correspond to alkalinity as generally measured. Wilson mentions this and shows that for a pH of 8.6, for which a theoretical alkalinity of 0.16 p.p.m. of NaOH is necessary, the amount actually found was, in the case of distilled water, 4 p.p.m. and, for Cambridge tap water, 7 p.p.m. For a pH of 10.0; 17 and 40 p.p.m. respectively were found against a theoretical of 4.00. These data we have checked as follows. With a definite alkalinity (to phenolphthalein) due to magnesite the corresponding pH was found to be as follows:

DISTILLED WATER		PITTSBURGH WATER	
Alkalinity	pH	Alkalinity	pH
0	6.8	0	6.2
5	8.2	5	8.4
15	9.8	15	9.0
30	10.0	30	10.0

Apparently as high an alkalinity as 30 p.p.m may be obtained with a pH of only 10. Considerably less than this alkalinity will often produce clear water, but even 30 p.p.m. alkalinity due to magnesite is not sufficient to inhibit corrosion to any great extent or to form a decidedly protective coating by ferric hydroxide *per se*.

F. N. SPELLER,[4]
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ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Cost of Water Purification at St. Louis. Ann. Rep. Water Commr. 1922. Eng. Contrg., **58**: 144, 1922. Costs for 5 years are detailed, varying from $7.43 to $12.08 per million gallons.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Uniform Policy on Degree of Treatment of Sewage Discharge into Delaware River. Eng. Contrg., **58**: 142–3, 1922. Pub. Wks., **53**: 110–1, 1922. Mun. Cty. Eng., **62**: 63–4, 1922. The commissioners of health of New Jersey and Pennsylvania have agreed on a policy requiring sedimentation in lower river, with suitable qualifications where water works are affected, and in upper river clarified and oxidized effluent. So far as practicable industrial wastes are to be treated.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Treatment of Hard Impure Waters with Alum. WILLIAM GORE. Can. Sect. Am. W. W. Assn., 1922. Eng. Contrg. **58**: 134–5, 1922. Can. Engr., **42**: 519–21, 1922. In the treatment of water with $Al_2(SO_4)_3$ an increase of bicarbonates in the water or increase in organic matter requires more coagulant. The optimum amount of $Al_2(SO_4)_3$ increases with alkalinity of water. The H-ion concentration is a measure of the amount of coagulent required. The proper amount can only be determined by experiment.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Water Treatment on Missouri Pacific R. R. Eng. Contrg., **58**: 133, 1922. Mo. Pac. R. R. saved net $443,369.00 in 1921 by treating water in 77 plants, over the cost of treatment ($170,575).—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Prevention of Sewage Contamination in Ontario. F. A. DALLYN. Can. Sect. Am. W. W. Assn., 1922. Can. Engr., **42**: 522–4, 601–2, 1922. The Ontario Provincial Board of Health is actively endeavoring to protect water supplies. Branch laboratories have been established.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

River Intake Difficulties. FULLER AND MCCLINTOCK. Pub. Works **53**: 196–7, 1922. The Mississippi River has a range of 46 feet. An intake structure would be 150 feet high. The river bed shifts. Intake pier or tunnel would cost $1,000,000 or more. Continued use of artesian well supply was advised.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Don'ts for Sewerage and Waterworks Designers. Minn. State Board of Health, Pub. Works, **52**: 457-60, 1922.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Combination of the Lime Soda and Zeolite Water Softening Process. L. M. BOOTH. Mun. Cty. Engr., **62**: 220–1, 1922. L. M. B. advocates a residual hardness of less than 85 p. p. m. and even below 50.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Concrete Pipe with Improved Joints Used in St. John, N. B. Eng. Contrg., **57**: 567, 1922.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Closing 42-inch Outlet Pipes in Shoshone Dam under 200 feet of Water with Wooden Balls. J. S. LONGWELL. Eng. Contrg., **58**: 257–8, 1922.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Floating Islands in Storage Reservoir. Pub. Works, **35**: 195, 1922. Eng. Contrg., **58**: 1261–2, 1922. In a reservoir at Charleston, S. C., floating masses of marsh grass and roots have blown around and carried rank growths of aquatic plants. One hundred twenty-five acres were removed at cost of $54.20 per acre, by a rake on a dragline, operated by hoisting engine on two 8×16 ft. scows. Dissolved O in H_2O has increased since removal.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Business of Water Works Management. GEORGE H. JOHNSTON. No. 212, Am. City Pamphlets. Can. Engr., **43**: 501–3, 1922. George H. Johnston discusses management of municipal water works, rate making, urging pay-as-you-go policy on financing. Advocates no free water. By making a bridge, a minimum rate can be fixed and other charges for fire hydrants, etc.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Pumping Plant of New High Pressure Fire System at Buffalo, N. Y. W. B. POWELL. Mun. Cty. Eng., **62**: 177–9, 1922. New 20-in. cast iron pipe installed to carry 300 lb. pressure, supplied by 3 stream-turbine driven 4-stage centrifugal pumps each of 3000 gal. per min. Turbines run non-condensing, 3170 r.p.m., geared to pumps at 1500 r.p.m.—*Langdon Pearse.* (*Courtesy Chem. Absts.*)

Lead in Drinking Water. CHARLES D. HOWARD. Am. J. Pub. Health, **13**: 207, 1923. Experience in New Hampshire shows lead poisoning occasionally caused by water contg. 0.25 p.p.m. Pb., although arbitrary maximum of 0.5 p.p.m. has been adopted. Use of lead pipe more common in New England than in rest of U.S. Details of H's modification of standard method for detn. of Pb are given.—*Jack J. Hinman, Jr.* (*Courtesy Chem Absts.*)

The "Dionic Water Tester." BOUSQUET. La Nature (Supplement), 2549, **45**: February 10, 1923. Description with diagrams and photograph of the apparatus of Digby and Biggs for determining the conductivity of waters for the purpose of noting changes in composition.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

A New Selective Medium for the Cholera Vibrio. H. KODAMA. Centralb. f. Bakt., I Orig. XX, **88**: 433, 1922; Bul. mens. office intern. d'hyg. publ., **14**: 1532, 1922. Medium is a starch agar on which cholera organism shows an area surrounding colony in which starch has been broken down. Media prepared as follows: Boil in steam sterilizer for ½ hour 100 cc. 3 per cent agar neutral to litmus, 1 cc. of 10 per cent solution Na_2CO_3, 0.5 cc. saturated alcohol solution fuchsine (basic?); 2.5 cc. fresh 10 per cent solution Na_2SO_3; 3 grams potato starch suspended in 5 cc. H_2O. Boil also ½ hour a dilution of 20 cc. beef serum in 80 cc. H_2O and 1 cc. 10 per cent NaOH. Mix 2 pts. solution 1 and 1 pt. solution 2. Pour into petri dishes using care to distribute starch evenly. Description of the growth of cholera vibrio, the similar Mechnikoff, Deneke, and Finkler-Prior organisms as well as other bacteria—*Jack J. Hinman, Jr.*

The Treatment of Goiter by Iodine and Its History. E. BIRHER. Schweizer. med. Wochenschrift., July 20, 1922, p. 713: Bul. mens. internat. office d'hyg. publ., **15**: 127, 1923. Birher contends that that on account of the uncertainty concerning physiological and pharmacological action of iodine and its action on the normal and abnormal thyroid and other glands, the use of iodine cannot properly be recommended.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

The Treatment (of Goiter) by Iodine under Scientific Control. MAX EDWIN BIRCKER. Schweizer. med. Wochenschrift., August 31, 1922, p. 862; Bull. mens., office internat. d'hyg. publ., **15**: 127, 1923. The dangers of use of iodine are avoided by method used in America and based upon the knowledge of the function of the thyroid obtained by a study of the basal metabolism of the patient.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

Action of Natural Waters on Lead. J. C. THRESH. Analyst, **47**: 459-468, 500-505, 1922; Jour. Soc. Chem. Ind., **42**: 159 A, February 23, 1923. Differences observed in action of natural waters on lead are probably due to varying amounts of silicates, carbonates, sulphates, and salts of some organic acids, together with these organic acids and free carbon dioxide, present in the waters. Small quantities of silicates prevent oxidation of lead, iron, and aluminum, and moorland waters no longer attack lead when they have been treated with sodium silicate.—W. P. S.—Courtesy *A. M. Buswell.*

Disinfection of Drinking Water by Chlorine. H. BRUNS. Gas-u. Wasserfach, **65**: 713-716, 734-739, 752-756, 764-770, 1922; Jour. Soc. Chem. Ind., **42**: 159 A, February 23, 1923. Developments in use of hypochlorites and chlorine for sterilization of drinking water during past ten years and methods of chemical control. Automatically controlled plants at Pforzheim, Bochum, and Altoona are described. In the first two, salt solutions are electrolysed in glazed earthenware tanks using carbon electrodes. Proportionate amounts of resulting hypochlorite are mixed with the water to be treated. At Altena a measured fraction of the water passing through the main is by-passed by a Venturi-tube device and saturated with chlorine in a steel cylinder under a pressure of 5 to 6 atm. Chlorine water so formed is remixed with bulk of water.

Disadvantages in use of bleaching powder compared with sodium hypochlorite or chlorine are probably outweighed by its much lower cost.—S. P.—Courtesy *A. M. Buswell.*

The Norwich Flood, 1912. CAPT. H. WOOD. Jour. Royal San. Inst., **42:** 6, 347, May, 1922. In Norwich flood, 1912, average rainfall for 24 hours was 5.08 inches over 2044 square miles.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Vancouver's Water Supply Problems. ANON. Contract Record, **36:** 38, 935, September 20, 1922. Inadequacies in distribution system, due to rapid growth in population, have caused water shortage.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Development in Swimming Pool Construction. WALTER ATHERTON. Jour. Amer. Assoc. Hygiene and Public Baths, **4:** 4, 27, 1922. Construction materials and waterproofing methods are discussed.—*A. W. Blohm.* (*Courtesy I. W. M.*)

The Sanitation of Bath Houses. W. P. GERHARD. Architecture and Building, 1923. Location, construction, equipment and safety devices of swimming pools, piping, heating water and laundry of bath houses are discussed.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Municipal Swimming Pools. Domestic Eng., **102:** 1, 26, January 6, 1923. Pools are grouped into four classes ranging from $2000 to $3000 up to $100,000 to $500,000. Equipment including filters, disinfectors, chlorine, ozone, ultraviolet rays, heaters, shower and toilet facilities. Plans showing detailed arrangement of pools—*A. W. Blohm.* (*Courtesy I. W. M.*)

Municipal Outdoor Swimming Pools. CHARLES ELLIOT. Eng. and Cont., **58:** 1, 16, November 29, 1922. Design features and construction details with discussion on selection of site. Floating baths constructed on pontoons rising and falling with water level.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Montreal Filtration Plant. Can. Eng., **43:** 21, 557, November 21, 1922. Construction of 50 million reinforced concrete, filtered water reservoir to supplement existing 50 million gallon filtration plant.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Is Chlorination Necessary for Municipal Water Supplies? American City, **28:** 4, 337, April 1923. Survey of typical cities in Indiana gives almost unanimous agreement that chlorination is necessary. Reduction of water-borne typhoid in cities where used.—*A. W. Blohm.*

Sanitary Obligations of Municipalities to Tourists. American City, **28: 4,** 385, April, 1923. Need of providing safe water supply and proper disposal of sewage, garbage and other wastes.—*A. W. Blohm.*

St. Louis Water-Works Extension Assured. American City, **28**: 4, 391, April, 1923. Passage of bond issue for $12,000,000 eliminates threatening drought. New water works to be located on Missouri River, 14 miles west of city limits.—*A. W. Blohm.*

The Federal Power Commission. MILTON CONOVER. Service Monographs of the United States Government, No. 17. This recently published book was prepared for the purpose of furnishing an essential tool for efficient legislation, administration and popular control and for laying the basis of critical and constructive work.

Historical review of water power development from the time of the colonies to the present Federal Power Commission. Latter conducts investigations, issues permits and licenses, disposes of legal and judicial questions arising from Federal Water Power Act, and coöperates with public and private agencies in carrying out provisions of act.

The Secretary of War, Secretary of the Interior and Secretary of Agriculture comprise the Federal Power Commission with a working unit composed of about thirty-five persons.

Appendix contains outline of organization, classification of activities, publications, laws, general procedure for administration of the Federal Water Power Act, financial statement and statistics on water-power resources and installed capacity of water wheels in the United States, by States and by geographic divisions.—*A. W. Blohm.*

Moberly, Missouri, Enlarges Water Supply. GORDON HUDELSON. American City, **27**: 335, October, 1922. New reservior with present one makes supply of 500,000,000 gallons available to city of 13,000 population. 2,000,000 gallon per day filter plant constructed.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Recent Progress in Sanitary Engineering in Bengal. G. BRONSBY WILLIAMS. Local Self-Government Gazette, **8**: 11 and 12, 557 and 614, November and December, 1922. Source of Gaya supply is Phalger River which flows alongside headworks. Filtration gallery is formed of row of open jointed 24-inch pipes laid 700 feet into river on clay under water and surrounded by graded gravel. Water from well and gallery is pumped into pair of circular reinforced concrete reservoirs with total capacity of 8000 gallons. The Jharea coalfields supply will serve 200,000 people. Supplies pumped from wells are given 2 to 4 days settlement period before passing through slow sand filters. During monsoon period water is treated with 8 g.p.g. of alumino-ferric with 36 to 48 hours settlement.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Providing for the Supply of Potable Water to the Cities in the Interior of the Republic of Uruguay. Boletin, Consejo Nacional De Hygiene, **17**: 16, 425, July, 1922. Sum of $300,000 appropriated for this purpose. $22,000 of this is for installation of aluminum sulphate manufacturing plant. Department of sanitation to prepare specifications for public water supplies in various towns. *A. W. Blohm.* (*Courtesy I. W. M.*)

Softening Boiler-Feed Water with Zeolites. Power, **56**: 412, September 12, 1922. How the zeolites remove hardness; details of operation; data on a typical installation; combination lime-zeolite treatment for water high in temporary hardness. Illustrated.—*Geo. C. Bunker.*

How to Select Steam-Cylinder Oil. W. F. OSBORNE. Power, **56**; 421, September 12, 1922. Brief summary of influence of operating conditions of steam engine on various physical and chemical properties of steam-cylinder oils.—*Geo. C. Bunker.*

Evaporators in the Stationary Power Plant. Power, **56**: 449, September 19, 1922. Evaporator refers to a piece of apparatus using steam to distill raw makeup water for boiler feed. Chief purpose of evaporator is to eliminate evil of boiler scale, not by removing scale after it is formed, or by chemical treatment of scale-forming impurities, but by furnishing distilled makeup water practically free from all dissolved solids, scale forming or otherwise. High pressure and low pressure evaporators are described. Illustrated.—*Geo. C. Bunker.*

Leveling an Engine on its Foundation. G. GROW. Power, **56**: 409, September 12, 1922. Practical directions for removing engine from flat car; lowering onto foundation; method of finding center line; and for lining up. Illustrated.—*Geo. C. Bunker.*

Notes on Air-Compressor Lubrication. W. F. OSBORNE. Power, 56: 490, September 26, 1922. Oils of the following Saybolt viscosities are recommended for satisfactory service as far as lubrication is concerned: Single-stage, horizontal or vertical double-acting; pressures to 50 lbs., 290-310; pressures to 100 lbs., 700-400; Two-stage, horizontal or vertical double-acting; pressures to 50 lbs., 190-210; pressures to 100 lbs., 290-310: Multi-stage, horizontal or vertical double-acting; 290-800: Single-stage, vertical inclosed crank case, splash lubricated; pressures to 50 lbs., 290-310; pressures to 100 lbs., 700-800. These viscosities are for naphthene oils; paraffin oils should have viscosities about 10 per cent lower in order to get the same results. When compressors are to be operated outdoors in winter weather, the oil should have a sufficiently low pour test so that it will remain fluid at the lowest temperature likely to be encountered.—*Geo. C. Bunker.*

Stop Valves and Header Connections. W. H. WAKEMAN. Power, **56**: 486, September 26, 1922. Discussion of proper installation and operation of pipes and valves connecting two or more boilers to a header so that draining will be automatic and will not depend on manual adjustment of drip valve. Well illustrated.—*Geo. C. Bunker.*

Cause of Carbon in Air Compressors. W. F. OSBORNE. Power, **56**: 533, October 3, 1922. Lubricating oil applied to air cylinder vaporized and atomized by swirling action of air and carried to all part of cylinder and valve chamber. The only way oil can get out of cylinder is through air discharge

valve. Any oil not quickly atomized or vaporized will remain in cylinder considerable time, and accumulation of liquid oil results in all depressions on cylinder and piston heads, discharge valves, etc. From continued exposure to heat and pressure oil slowly decomposes, and a sticky, adhesive mass of carbon and oil builds up. Carbon deposits are undesirable for many reasons. If they collect around the piston rings, rings will stick and, not being flexible, will not maintain the proper seal for piston. Piston and rings, not being properly lubricated, begin to wear; cylinder sometimes scores, and general efficiency of compressor is lowered. Continued accumulation of carbon on valve and valve seat prevents proper cooling of valve and latter becomes overheated. In addition to crystallizing the metal, drawing its temper, and warping it so that it can not seat properly, carbon works between valve and seat, preventing tight closing. A fundamental principle is to use just as little oil as possible. Better to use fairly volatile oil than one of low volatility, even though slightly greater amounts are used. Straight-run oil more satisfactory than blended oil, as not so likely to form carbon deposits. Pure mineral oils of proper viscosity should always be used. Compounded oils never. Steam cylinder oils not satisfactory as a whole and should be replaced with lighter-viscosity oil. Filtered oils are less likely to form deposists than non-filtered oils.—*Geo. C. Bunker.*

Corrosion—Its Cause and Cure. Power, **56:** 532, October 3, 1922. Corrosion of commerical iron and steel by ordinary water due almost entirely to dissolved oxygen. Difference of opinion concerning nature of changes which take place. In majority of cases, corrosion will stop if dissolved oxygen is removed and prevented from reentering water. One method of removing oxygen is to bring the water in contact with mass of iron or steel of low price. In this way oxygen will corrode latter and water will lose corrosive power before passing into pipes or boilers. In Kestner process water is passed through tank of steel turnings, known as a "degasser," with piping and valves so arranged that water may be given upward or downward flow. Rust that forms on the turnings in lower half of "degasser" slows up action of oxygen on metal so that it becomes necessary to remove rust. This is done by reversing flow of water. Upper half of turnings then become available for oxygen to act upon while rust is being washed off lower half. Turnings consumed save about five times their weight of more expensive metal in pipes, boilers, drums and tubes. Turnings of different chemical composition are used to obtain maximum efficiency from a "degasser." Great care must be used to prevent entrance of air into water from which oxygen has been removed. The Kestner "degasser" is ordinarily used in connection with Kestner continuous feed-treatment and blow-down system. Illustrated.—*Geo. C. Bunker.*

Setting Valves on Nordberg Unaflow Engine. Power, **56:** 800, November 21, 1922. Unusual feature of valve design is employment of cages in which valves rest and which in turn fit into cavities in the heads, these cages being sealed by a ground joint and held down by valve bonnet. In many engines there is considerable difference in expansion of valve and of cylinder casting in which it seats. If valve is double-beat, as is almost imperative in order to avoid ex-

cessive lift, this difference in expansion will cause leaks between valve and one of seats. By placing valve in a cage made of metal from the same heat as valve, rates of expansion of valve and seats are identical and leaks are eliminated. To avoid excessive compression pressure if vacuum is lost when operating condensing, a positively operated auxiliary exhaust valve is placed at each end of cylinder. Operating and setting of these valves explained. Illustrated.—*Geo. C. Bunker.*

How a Lillie Evaporator Operates. Power, **56**: 802, November 21, 1922. During last seven or eight years a considerable number of installations of evaporators have been made in large power plants. Evaporators may be divided into two classes—those that use exhaust steam to evaporate raw water and those that use high-pressure steam. Article deals with one type of former class, the Lillie multiple-effect evaporator. Operation given in detail. Illustrated.—*Geo. C. Bunker.*

The Flash Evaporator. Power, **56**: 834, November 28, 1922. Evaporator in which evaporation takes place in chamber containing no tubes. Accomplished by circulating raw water continuously through closed heater, operated by exhaust steam, to a vacuum flash chamber or evaporator and then back to heater. Advantages are claimed for flash evaporator: Elimination of evaporator scale trouble; removal of air and other gases; automatic control of evaporator feed and evaporator blowdown; and high rate of heat transmission in heater, due to absence of steam film between tubes and surrounding water. Illustrated.—*Geo. C. Bunker.*

A Unaflow Engine with an Unusual Valve Gear. Power, **56**: 843, November 28, 1922. A description of the valve gearing in the Hamilton Unaflow Engine built by Hooven, Owens, Rentschler Co. and method of setting valves. Illustrated.—*Geo. C. Bunker.*

Boiler Tube Failures. HAYLETT O'NEIL. Power, **56**: 876, December 5, 1922. Eight-boiler plant employing single-pass horizontal baffling, was 140 tube failures in 60 days. Careful study revealed cause. Remedy applied reduced loss to less than five tubes per year. Illustrated.—*Geo. C. Bunker.*

Unaflow Valve Gear of American Design. Power, **56**: 880, December 5, 1922. Description of several valve gears used on Filter & Stowell Unaflow Engines and method of setting valves. Illustrated.—*Geo. C. Bunker.*

Water Supply and Water Treatment. Health Notes, Bull. State Board of Health of Florida, **14**: 7, 119, November, 1922. Recent steps towards improvements to various public water supplies in Florida.—*E. S. Chase.*

Water Supply Improvements. Monthly Bull., Indiana State Board of Health, **25**: 7, 75 and 84, July, 1922. Water supply improvements in Indiana.—*E. S. Chase.*

Report Dept. Food, Drugs, Water and Sewage. Monthly Bull., Indiana State Board of Health, **25:** 8, 92, August, 1922. Work of department with water supplies. Instance of reservoir contamination by B. coli from pigeons. Use for drinking purposes by tourists and visitors, of polluted water supply which, although not intended for potable purposes, was acessible at taps around city.—*E. S. Chase.*

1921 Report, Board of Health, Montclair, N. J. Page 24. Account of outbreak of intestinal disease of February, 1921, attributed to presence of B. Welchii in public water supply.—*E. S. Chase.*

Recent Advances in Sanitation. GEO. C. WHIPPLE. Health News, Monthly Bull., N. Y. State Dept. Health, **17:** 9, 196, September, 1922. In this paper under "Water Purification" Whipple refers to establishment of principles of water filtration, chlorination and methods for removal of tastes and odors. Refers to problems of B. coli, B. welchii, of coagulation and of standards of quality for drinking water.—*E. S. Chase.*

A New Method of Purifying Water. H. W. CLARK. The Commonwealth, Mass. State Dept. Public Health, **9:** 5, 281, September–October, 1922. Method for purification of comparatively clear, highly colored New England waters by impregnation of sand of slow sand filters with aluminum hydroxide. Such filters may be operated at from 5 to 6 million gallons per acre daily. Regeneration of coagulant secured by application of solution caustic soda. Method has advantages: (1) practically no increase in corrosiveness of filtered water and no coagulant present in filter effluent, (2) the coagulant may be used over and over by regeneration; (3) method of regeneration removes practically all deposited organic matter from filter and scraping is largely obviated; (4) practically no consumption of alum. Clark estimates that with this method cost of chemicals, sulphate of alumina and caustic soda, at about $3.05 per million gallons of Merrimack River water filtered, while with ordinary mechanical filtration cost would be $6 to $7 per million gallons for sulphate of alumina. Bacterial efficiency of process is poor, but may be corrected by chlorination. Experimental filters operated over period of five years at Lawrence. In the case of the five filters for which Clark gives data, the sand was loaded with sulphate of alumina in amounts equivalent to 80 to 225 tons per acre of 4.5 feet depth; color removed from 66 to 78 per cent; periods between caustic treatment from 65 to 90 days; 0.16 to 0.52 grain of caustic soda per gallon of water filtered and 2.5 to 5.5 per cent of filtered water used for washing filters.—*E. S. Chase.*

Cause of Decrease in Typhoid Rate in the United States. GEORGE C. WHIPPLE. Eng. News-Record, **89:** 794, 1922. Curves plotted on semi-log paper show changes in typhoid rates occurring in 2 states and 6 cities. Method recommended as it accentuates breaks in the curves. Improvement of water and milk supplies factors in decrease of typhoid rate.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Study of Typhoid Causes Needed. EDITORIAL. Eng. News-Record, **89:** 776–7, 1922. Coöperative study by city, state and government should be made to determine individual causes of typhoid rate in various cities.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

An Experience with Air-Binding of Rapid Filters. WILLIAM D. HATFIELD. Eng. News-Record, **89:** 783–4, 1922. Air accumulations in sand beds at Highland Park, Mich. reduces period of filter-run from 20 to 50 per cent. Leaky pump glands permitted air to be sucked into water, thereby supersaturating the water with O. This supersaturation still persisted even after passing through coagulating basins. Repairing pumps relieved trouble from air-binding.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Filters for Duluth Water Supply Considered Unnecessary. H. A. WHITTAKER AND J. A. CHILDS. Eng. News-Record, **89:** 937, 1922. Intensive investigation by State Bd. of Health indicates filters not required at present. Filtration would only reduce low turbidities. City water meets standards of United States Treasury Department for interstate carrier water supplies.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Percentage of Water Pumped which Produces Revenue. H. F. HUY. Eng. News-Record, **89:** 944–5, 1922. Western N. Y. Water Co., operates in suburbs of Buffalo and supplies about 60,000. About 90 per cent of the water pumped is revenue-producing. System is 100 per cent metered. High revenue-producing percentage possible by careful inspection of house connections, pitometer surveys, maintaining meters in good registering condition, and checking up water pumped against water registered.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Small Iron Removal Plant for Water-Works of Leroy, Ohio. A ELLIOTT KIMBERLY. Eng. News-Record, **89:** 965–7, 1922. Water supply obtained from flowing well 75 feet deep with capacity of 150,000 gal. per day. Raw water contains 2.0 p.p.m. Fe, 64 p.p.m. CO_2, and no O. Fe removal plant consists of aerator, roughing filter and rapid sand filter. Kimberly states that roughing filter is more effective than sedimentation after aeration in coagulating Fe. Plant removes all Fe and CO_2, and increases O content of water to 68 per cent saturation.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Water Treatment Works of Buenos Aires, Argentine Republic. MARIO L. NEGRI AND HENRY W. WENDT. Eng. News-Record, **89:** 602–3, 1922. Population of Buenos Aires 1,500,000. Water supply obtained from the Rio de la Plata. It is pumped to coagulation and sedimentation basins where alum is added. Water is filtered through 10 slow sand filters with total area of 13.3 acres. Coagulation and sedimentation basins remove 80 to 90 per cent bacteria. No results on filter efficiency given.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Filtered Well Water Recommended for Memphis, Tenn. FULLER AND MCCLINTOCK. Eng. News-Record, **89**: 566–7, 1922. Report compares cost of well water and Mississippi River supply. Concluded that after iron and CO_2 are removed the well water supply is softer, cooler and produced cheaper than filtered Mississippi River supply. Fe may be removed by aeration through nozzles, coke beds or addition of CaO. Well supply contains 90 to 130 p.p.m. CO_2 and 0.2 to 0.6 p.p.m. Fe. Proposed to sink 24 wells having a capacity of 1 m.g.d. each.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Extensive Boiler-Water Treating on C. M. & St. P. Ry. C. HERSCHEL KOYL. Eng. News-Record, **89**: 560–2, 1922. Operating condition on C. M. & St. P. Ry. much improved by installation of water softening plants. Typical plant consists of soln., mixing and sedimentation tanks. Lime, soda ash and $FeSO_4$ are added. Thorough stirring of mixture for 25 to 50 minutes in mixing tank is essential for complete pptn. Plants have capacity of 15,000 gallons per hour. Sludge removed by opening valves for 30 seconds controlling a system of perforated sludge pipes lying on bottom of settling tank.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Cleaning a Mixing Conduit of Lime Deposits. C. M. DAILY. Eng. News-Record, **89**: 695, 1922. After few months service mixing conduit at St. Louis waterworks had 2 feet of soft mud on bottom and small amount of lime scale on sides. Deposits removed by means of disc harrowed through conduit.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Water Supply Permit Applications in New York State, 1905–22. RUSSELL SUTER. Eng. News-Record, **90**: 27, 1923. General uniformity in number of applications from 1908–1916 is noted, showing a yearly average of 22. Slacking up due to war is marked with increase in application during 1920 because of dry weather and decline in construction cost.—*Frank Bachmann.*

What Cities Must Spend Annually for Their Water Supplies. C. B. BUDRICK. Eng. News-Record, **90**: 27, 1923. Average city of 100,000 must spend about $5,200,000 for new water works construction during 23 years. Operation and fixed charges make cost of water approximately $3.76.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Use of Copper Sulphate at Hartford and Effect on Filter Runs. J. E. GARRETT. Eng. News-Record, **89**: 1124–5, 1922. Microörganisms, principally Asterionella and Uroglena, shortened runs on filters at Hartford, Conn.; 2.3 pounds $CuSO_4$ per million gallons reduced number of organisms and aided in increasing filter runs.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Determining Sub-Surface Water Flow Electrically and Chemically. J. W. TOYNE. Eng. News-Record, **90**: 698, 1923. A central well 12 inches diam. was surrounded by 2½ inch wells at radius of 6 feet and at depth of 155 feet into gravel formation at South Bend, Ind. About 200 pounds of salt and basic fuchsin were placed into central well. Surrounding wells were equipped with

electro-couples connected with the 110 volt lighting circuit through an ammeter. Current readings and samples taken hourly. 82 hours required for a flow of 5 feet.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Experiments on Formation of Floc for Sedimentation. EDWARD S. HOPKINS. Eng. News-Record, **90**: 204–5, 1923. Experiments carried out at Montebello Filters, Baltimore on a mixing basin 118 feet wide 191 feet long and 18 feet deep baffled so as to give 24 channels 8 feet wide. Total distance traveled by water is 9.56 mile with a detention of 31.8 minutes at 128 m.g.d. rate. Samples taken at extreme end of basin always settled in shortest time at all velocities. Good mixing was had after passing the first few "turns" at baffles but less time for sedimentation was noted at each subsequent "turn." *Frank Bachmann.* (*Courtesy Chem. Absts*).

The Apulian Aqueduct—Southern Italy's Water Supply. I. GUTMANN. Eng. News-Record, **90**: 389–94, 1923. Aqueduct nearly completed. Will supply 266 communities scattered over area of 8100 sq. miles having a population of 3,000,000 people. Source is the Caposele Springs. Daily water consumption allowance varies from 10.6 to 24 gallons per capita. Water is soft and practically free of organic and mineral matter.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Water Consumption in New Jersey Declines. H. T. CRITCHLOW. Eng. News-Record, **90**: 251, 1923. Average daily per capita consumption was 114 gallons in 1914, 117 in 1918, and 109 in 1921. Decline is mainly due to increased use of meters. Population supplied in 1921 was 2,950,000 and volume 321,880,000 gallons daily.—*Frank Bachmann.*

Water Consumption and Meters at Woonsocket, R.I. ANON. Eng. News-Record, **90**: 399, 1923. For year 1921, per capita water consumption was 50.7 gallons. Of total consumption, 79.9 per cent was metered and 98 per cent of services are metered.—*Frank Bachmann.*

Copper Sulphate Keeps Down Najas Gracillima. J. F. JACKSON. Eng. News-Record, **90**: 500, 1923. By use of CuSO this growth was eliminated. Somewhat similar to eel grass and only trouble experienced was its accumulation on intake screens.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

How the Johnstown Water Company Met the Recent Drought. C. W. KUNKLE. Eng. News-Record, **90**: 451, 1923. Because of severe drought in Pennsylvania in latter part of 1922, City of Johnstown was compelled to resort to emergency water supply owned by Cambria Steel Co. Latter supply is used for industrial purposes only, but by chlorination it was made safe.—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Treatment of Water Contaminated by Mine Drainage. J. W. LEDOUX. Eng. News-Record, **90**: 698, 1923. Five methods considered. (1) neutralization by lime and soda ash, which leaves impractical am'ts of Na_2SO_4 in water;

(2) neutralization with lime, removal of ⅓ of the SO_4 by heating to 356°F., using heaters and boilers and treating remaining H_2O with soda. The final H_2O would contain 270 p.p.m. Na_2SO_4 and cost 15 cents per 1000 gallons (3) neutralization with lime and evaporation costing 32 cents per 1000 gallons; (4) $Ba(OH)_2$ treatment costing 45 cents per 1000 gallons; and (5) first removing ⅓ of $CaSO_4$ by heat, then treating with $Ba(OH)_2$ costing 28 cent per 1000 gallons. Ba treatment is expensive but offers the most promise. Safeguards to prevent danger from poisoning may be adopted..—*Frank Bachmann.* (*Courtesy Chem. Absts.*)

Serious Water-Borne Typhoid Outbreak at Cochrane, Ontario. F. A. DALLYN. Eng. News-Record, 90: 714, 1923. Source of epidemic laid to water supply, obtained from springs and from Spring Lake receiving overflow from springs. Outlet of Spring Lake connects with lake receiving sewage. Due to dry autumn water supply has been greatly taxed. Spring Lake had been lowered 3 feet below Sewage Outlet Lake causing contaminated water from latter to flow into Spring Lake, resulting in 600 cases of typhoid and 20 deaths. —*Frank Bachmann.* (*Courtesy Chem. Absts*).

Water Softening at Columbus, Ohio.—Results and Studies. C. P. HOOVER. Eng. News-Record, 90: 671, 1923. Total cost of softening water during past 14 yrs. has averaged $22.9 of which $16.38 p.m.g. was for chemicals. To reduce hardness 1 p.p.m. it has taken 10.7 pounds CaO or 11.5 Na_2CO_3 per million gallons. Tests indicate that reaction between chem. added and Ca and Mg in the water is immediate. Ninety per cent of reaction takes place in the mixing basin, 3 per cent in 15 hours through settling basins and 7 per cent in passing through filters. Average hardness in river water 273; influent to settling basins, 119; outlet of basins, 113; and filtered water, 101 p.p.m. Figures indicate large settling basins are unnecessary. Filters more effective in removing colloids than settling basins. Both Columbus and new Newark, Ohio plants are arranged so as to add all of chemicals to 25 per cent of water and subsequently mixing with remaining 75 per cent. Addtion of $Al_2(SO_4)_3$ with lime and soda improves character of floc. A CO_2 plant consisting of coke burner, blower for sucking gases from burner to absorber was experimented with. CO_2 enters at bottom of absorber and water dropping onto revolving disc dissolves gas. Carbonated H_2O from absorber contains as high as 600–700 p.p.m. CO_2. About 171 pounds CO_2 required to carbonate 1 m.g. of Columbus softened water.—*Frank Bachman.* (*Courtesy Chem. Absts.*)

Water Required for Paper Making. W. G. FRASER. J. Soc. Chem. Industry, 41: 531R, December 15, 1922. In report of paper by Fraser at meeting of Manchester Sectn., Soc. Chem. Industry, F. states that 100,000 to 150,000 Imp. gal. are required for 1 ton of rag paper, 10,000 to 12,000 Imp. gal. for 1 ton of newsprint paper, for all purposes, including steam making.—*Jack J. Hinman, Jr.*

New Method for the Detn. of Manganese. MINOVICI AND KALLO. (University of Bucharest.) Chimie et Industrie, 8: 3, 499, September, 1922. Based

on reaction: $2HIO_3$ plus MnX_2 yields $Mn(IO_3)_2$ plus 2HX. The $Mn(IO_3)_2$ is reported to be insoluble in 70 per cent alcohol saturated with HIO_3. Wash precipitate with 70 per cent alcohol saturated with HIO_3, dry at 100°C. and weigh.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

Apparatus for Producing Potable Distilled Water J. CALAFAT. E. P. 189, 879, September 9, 1921. Jour. Soc. Chem. Ind., **42**: 115A, February 9, 1923. Vertical cylindrical drum, cooled by water jacket, is fitted at its upper and lower ends with plate formed with large central hole, and radiator tube of star-shaped cross-section is mounted concentrically within the drum, intervening space being open to the atmosphere. Impure water, delivered from tank above drum, runs down over porous material covering exterior tube, and hot combustion gases pass through tube to heat it to about 60°C. Dissolved air and gases are thus retained in distilled water which runs down wall of drum to collecting vessel. Outlet is provided at lower end of tube for collecting surplus impure water. Water may be "mineralized," e.g., by adding sodium bicarbonate and tartaric acid to impure water in upper tank, and allowing distilled water containing carbon dioxide to pass through vessel containing marble or limestone.—H. H.—*A. M. Buswell.*

Purification of Phenol-containing Liquors. H. S. DAVIS AND S. D. SEMENOW, Assrs. to The Koppers Co. U. S. P. 1, 437, 401, December 5, 1922. Appl., June 23, 1919. Jour. Soc. of Chem. Ind. **42**: 116A, February 9, 1923. Phenol-destroying microörganisms cultivated in humus material used for purification of liquors containing phenols (cf. U.S.P. 1,323,251; J. 1920, 80A)—J. R.—*A. M. Buswell.*

Aggressive Carbon Dioxide in Potable Water. J. M. KOLTHOFF. Zeits. f. Untersuchung d. Nahr. u. Genussmittel, **41**: 97–1921. Wasser u. Abwasser, **17**: 262, 1922. $CaCO_3$ is soluble to about 14 p.p.m. in distilled CO_2-free water. The relations of CO_2, HCO_3^- and $CO_3^=$ as given by Tillmans (Die Chemische Untersuchung v. Wasser u. Abwasser, Halle, (Saale), 1915, p. 95) were found to be accurate by K. up to 90 p.p.m. bound CO_2. Aggressive CO_2 is given in a table by Kolthoff.—*F. W. Mohlman.* (*Courtesy Chem. Absts.*)

Significance of Hydrogen-ion Determination in Water Analysis. J. M. KOLTHOFF. Zeitschr. f. Untersuchung d. Nahr. u. Genussmittel, **41**: 112–22, 1921. Wasser u. Abwasser, **17**: 262,1922. The hydrogen electrode is not satisfactory for detg. the pH of potable waters. The colorimetric method, using neutral red, is satisfactory. CO_2 can be calculated if the pH and HCO_3^- content are known.—*F. W. Mohlman.* (*Courtesy Chem. Absts.*)

The Chlorine Value of Water and Sewage. V. FROBOESE. Arb. a.d. Reichsgesundheitsamte, **52**: 211, 1920. Wasser u. Abwasser, **17**: 269, 1922. The chlorine-combining value of water or sewage should be determined in addition to the $KMnO_4$ oxygen consumed. Investigations by Froboese indicated that Javelle water (sodium hypochlorite) is preferable to the hypochlorite or

hypohromite of calcium. The determination of the bromine-combining value is superfluous. In slightly polluted waters the chlorine value is more significant than the oxygen consumed.—*F. W. Mohlman.* (*Courtesy Chem. Absts.*)

Untersuchung des Wassers an Ort und Stelle. H. KLUT. 4th revised ed., with 34 illustrations. 189 pp. Julius Springer. Berlin, 1922. Rev. in Wasser u. Abwasser, 17: 273, 1922.—*F. W. Mohlman.* (*Courtesy Chem. Absts.*)

Commissioners of Water Works in the City of Erie. Report for the Year Ending December 31, 1922. 25 pp., 2 graphs. The Water Commissioners present their annual statement, the financial side of which is admirably recorded. The average daily pumpage was 20,117,629 and the maximum 28,789,400 gallons. The cost of the water at the works was $27.279 (included in which are $0.482 and $0.143, for alum and hypochlorite of lime, respectively) and the final cost as delivered to the consumer was $43.358 per million gallons. The amount of water pumped per ton of coal was increased, notwithstanding an increase in the discharge head. A net addition to the surplus of $179,666.07 was made during the year. Services to the City of Erie for which payment has not been received now total $326,261.55. Metered and assessed sales of water, and annual receipts, operating and construction costs are expressed graphically. The quality of the water and its purification are not reported upon.—*R. E. Thompson.*

Surface Water Supply of Ohio River Basin, 1918. United States Geological Survey Water Supply Paper 473, p. 1–112.—*I. W. Mendelsohn.*

Surface Water Supply of Lower Mississippi River Basin, 1919–1920. United States Geological Survey Water Supply Paper 507, p. 1–47.—*I. W. Mendelsohn.*

Water Powers of the Cascade Range, Part IV. Wenatchee and Entiat Basins. GLENN L. PARKER AND LASLEY LEE. Water Supply Paper 486, M. S. Geological Survey, 1922. 80 pages. Describes an area in central part of State of Washington, on east slope of the Cascade Range, in Chelan County. Analyses and summaries are given indicating approximately the power resources of the area and the relative value of closer sections of the river systems. A scheme of power projects is outlined consistent with the highest ultimate development in the region.—*I. W. Mendelsohn.*

A Plea For Rational Inte-pretation of Hydrogen Ion Measurments. W. C. MOORE. Trans. Am. Electrochemical Soc., 41: 27, 1922, preprint. Chem. Abs., 16; 2248, 1922. In many systems actual hydrogen ion concentrations are of secondary importance as long as values lie within certain definite hydrogen ion regions. pH values conveninent in showing when several sets of results are of same order of magnitude, but when once this order is determined it seems better, more logical and more understandable to express actual concentrations in multiples of this "order of magnitude" figure.—*W. D. Hatfield.*

A Turbidity Standard. H. BECHHOLD AND F. HEBLEN. Kolloid Z., 31: 132, 1922. Chem. Abst., 17: 659, 1923. Recommend, as Standard Turbidity, of a soln. made by mixing equal volumes of 1/500 M BaCl and 1/500 M Hydroxylamine sulfate solutions made in glycerol.—*W. D. Hatfield.*

Surface Tension of Colloidal Solutions. H. SCHLEIFER. Kolloid Z., 30: 273–8, 1922. Various colloids studied lowered the surface tension of water, but gamboge and hydrous Al_2O_3 did not.—*W. D. Hatfield.*

Estimation of Alkalinity of Water and Culture Media. H. NOLL. Zeit. f. Hyg. Infektionskrankh., 95: 172–190, 1922; Chem Zentr., 93: IV, 1003, 1922. J. Soc. Chem. Ind., 41: 995A, 1922. Estimation of alkalinity by direct and indirect titration using methyl orange gives good results. Indirect method by expelling CO_2 by boiling is more accurate: though reason is not given. Limiting sensitiveness about N/1000 solutions. In titrating Fe waters Fe carbonates cause too high figure. Allow Fe to precipitate. The humates and silicates are estimated as carbonates. In using phenolphthalein titre of phenolphthalein should be determined and same quantity always used. Humates do not, but silicates do interfere when phenolphthalein is used. Azolitmin is similar in action but inferior to phenolphthalein. Alkalinity of media best determined by spotting on test papers. Phosphates in media are partly removed by neutralization and filtration.—*Jack J. Hinman, Jr.*

Determination of Available Chlorine in Hypochlorite Solution. F. DIENERT AND F. WANDENBULKE. Ann. Fals., 15: 338–9, 1922. J. Soc. Chem. Ind., 41: 979A, 1922. One cubic centimeter of $CaOCl_2$ solution is diluted with 1 liter of H_2O and 2 gm. $(NH_4)_2SO_4$ added to prevent formation of iodate. A few crysts. of KI are added and the liberated I is titrated by $HAsO_2$ using starch indicator. Compares well with Penot's and Gay-Lussac's methods.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

The Drinking Water Supply of Paris. DIENERT AND GUILLERD. La Nature, 2549: 85–92, 2550: 108–111, 1923. General and historical paper. Identical with paper by D. &. G. appearing in Rev. hyg., 44, 710, 1922 with addition of illustrations.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

Titration of Hypochlorite. I. M. KOLTHOFF. Rec. trav. chim., 41: 740–50, 1922. J. Soc. Chem. Ind., 42: 181A, 1923. Estimation of $CaOCl_2$ by KI in H_2SO_4 solutions is inaccurate because any chlorite present liberates I, in addition to that liberated by the hypochlorite. The latter is changed in part into former if solution is kept for a time. In bicarbonate solution the chlorite reacts very slowly with K or Na arsenite. Titration should be done quickly in presence of large excess of bicarbonate such as 5–6 gm. for each 50 cc. of bleaching powder solution. Boric acid introduces an error. Bicarbonate should be free from carbonate. Extraction of I by petroleum ether facilitates reading end point and increases accuracy.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

Simple Goiter, a Preventable Disease. ANON. Bul. Chicago School Sanit. Instruction, 17, (n.s.)41–3, March 17, 1923. Goiter is on increase in Chicago and Great Lakes region. Considered as due to iodin deficiency. It has rapidly increased in Portland, Ore., and Seattle and Tacoma, Wash., since use of mountain water supplies. A goiter survey is now under way in Chicago schools and clinics will be developed as needed. Details of iodine method of goiter prophy-

laxis (Marine and Kimball, J. Am. Med. Assn., 1921). McClendon (J. Am. Med. Assn., March 3, 1923) is quoted as saying that even in lower Miss. Valley 10 quarts of H_2O are necessary to get from the natural H_2O daily prophylactic dose (0.1 mgm.) of iodine used by the Swiss.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Absts.*)

Report of Special Committee on Spray Systems of Paint and Varnish Application. Circ. 18, National Paint, Oil and Varnish Assoc. Inc. (U.S.A.). 35th Annual Conv., November, 1922, 7 pp. The speed of application of paint by spraying varies from 3 to 21 times that of hand brushing, the higher ratios obtaining in the case of work of easy accessibility, e.g., oil tanks. Results similarly favorable to spraying are shown in the relative total costs (labour and materials) of the two methods, hand-brushing costs being from 2 to 2.5 times those of spray painting. The consumption of paint per unit area covered may be as little as one-half that of hand brushing; with antifouling and anti-corrosive paint for ships' bottoms made on a viscous shellac varnish basis the sprayed paint covered from 8 to 9 times the area of that applied with the brush. The uniformity of proportion between pigment and vehicle was found to be considerably more in the spray system than in hand brushing during application. The practicability of portable spray systems operated by a cylinder of compressed carbon dioxide or nitrogen has been demonstrated during the past year. (A. de W.)—*A. M. Buswell.*

Year Book American Engineering Standards Committee, 1923. "In a very real sense the American Engineering Standards Committee is a movement rather than merely a formal organization or federation" To those of us familiar with the scope of the work, this is a mere truism. It is impossible within the limits of an abstract to do justice to the many-sidedness and importance of the "projects." Officially the American Waterworks Association is cooperating in but one of these, namely, "Pipe Flanges and Fittings." Actually the Waterworks engineer will find that fully 25 per cent of the "projects" will have a more or less intimate bearing upon his everyday work. The original should be in the hands of every engineer.—*Frank Hannan.*

A Study of the Polution and Natural Purification of the Ohio River. I. The Plankton and Related Organisms. W. C. PURDY. U. S. Public Health Bull. 131, December, 1922. Report of biological studies only, of Ohio River, made during 1914–5 as part of a study of river investigations comprising hydrometry, stream pollution, sources and quality of water supply, and prevalence of water-borne disease. Author discusses physical, chemical, and biological conditions as factors in plankton life. Complete representation of methods employed in work and summaries of biological investigations in various districts, treated separately, into which river was divided. Summaries include conditions at and between the districts; population, pollution, currents, number and kinds of organisms. General summary of biological investigations, twenty charts, complete and comprehensive, of biological conditions, and excellent bibliography.—*Bernard S. Coleman.*

1921 Report, Vermont State Board of Health. Page 47. Tabulation of public water supplies in Vermont together with analyses.—*E. S. Chase.*

1921–1922, Biennial Report, Kansas State Board of Health. Pages 120 and 133. Forty per cent of total population of state of Kansas or 100 per cent of urban population supplied with public water supplies; 20 per cent of total population or 50 per cent of urban population supplied with surface water; 52 surface supplies and 195 ground water supplies; 20 per cent of the supplies furnish 50 per cent of water consumed. Only 8 surface supplies (1922) which do not have filter plants and most of these 8 have settling basins and chlorination. On page 139 is tabulation of water supplies.—*E. S. Chase.*

1920–1922 Biennial Report, California State Board of Health. Report Bureau of Sanitary Engineering. Page 122. Seventy-five per cent of water supplies of California derived from surface sources, remainder from ground water. Surface supplies protected by storage, chlorination or both. Very few filter plants. Typhoid death rate of California from 1916 to 1920 inclusive, 6.9; 6.9; 6.0; 5.4 and 4.8 per 100,000 population respectively.—*E. S. Chase.*

Connecticut State Dept. Health. Statistical Bulls., **37**: 2–4, 9.7, February and April 1923. No reported deaths from typhoid fever in Connecticut in either January or February, 1923, in a state population of about 1,500,000.—*E. S. Chase.*

Illinois State Dept. Health. Health News, **9**: 4; 90, March 1923. Semi-Annual Report, Div. Engineering and Sanitation. Outlines briefly activities of engineering division during latter six months of 1922 in relation to water supplies. No water-borne typhoid fever outbreak in Illinois during period covered.—*E. S. Chase.*

1921 Ann. Report Ontario Provincial Board of Health. Rep. Prov. Sanitary Engineer, p. 108. Brief account of activities of engineering division in 1921. Details of regulations relative to cross connections for auxiliary water supplies. Double check valves in accessible pits, with provision for testing tightness of checks are permitted.—*E. S. Chase.*

Connecticut State Dept. Health. Statistical Bull.3 **7**: 1: 4, January, 1923. 1922 typhoid fever death rate in Connecticut was 3.0 per 100,000 population.—*E. S. Chase.*

Hydrated Lime—Total and Available Calcium Hydroxide. A. S. Behrman and F. R. Porter. Jour. Ind. & Eng. Chem., **15**: 269, March, 1923. Experience indicates that total calcium hydroxide in hydrated-lime as arrived at through the usual methods of analysis is always greater than available calcium-hydroxide. Lime should be purchased on availability basis as arrived at through improved method of analysis rather than on total calcium hydroxide content. In the method suggested the lime when added to a solution of bicarbonate-of-soda converts such to normal carbonate to extent of available

calcium hydroxide present. One gram of unscreened lime is mixed with about 100 cc. of boiled distilled water. Heat for 30 minutes at or near the boiling temperature to insure precipitation of all magnesia. Cool and add 400 cc. of approximately 0.10*N* sodium-bicarbonate, previously made just neutral to phenolphthalein. Mix thoroughly for 15 minutes and allow to stand 3¾ hours. Make to 500 cc. volume filter and titrate 50 cc. of filtrate with 0.10 *N* acid using phenolphthalein as indicator. Cc. acid × 7.4 = per cent available calcium-hydroxide. Method leaves a filtrate with excess sodium-bicarbonate. Error due to solubility of calcium-carbonate less than 0.5 per cent (high). Data so far obtained are satisfactory; but time has not been available to accumulate sufficient evidence to prove general applicability of method.—*Linn H. Enslow.*

Integral Water-proofing for Concrete. ALFRED H. WHITE. Jour. Ind. & Engr. Chem., **15**: 150, February, 1923. Surface of fairly rich concrete (1:3), alternately wetted and dried, will water proof itself in time through deposition of calcium carbonate in pores of solid mass. Water-proofing will reside, however, mainly in skin and center of mass will still have capillary openings. In old concrete, long submerged in water, openings will be smaller because they become partly filled with concrete colloid or with water of crystallization or both. A concrete reservoir or tank having stood empty for some time will when again filled allow moisture to seep through concrete until "concrete-colloid has become swollen again. After this action has been completed seepage again ceases. Experimental data are given showing effect upon water-proof qualities of concrete to which had been added as an integral part various materials including hydrated lime, clay, petroleum residual, and various insoluble soaps, during mixing of mortar. Compressive strengths of concrete containing insoluble-soaps and hydrated-lime were somewhat increased through addition of water-proofing. Increased strength is explained but resistance against free capillary travel of water and consequent retarded drying out of concrete allowing a greater period for proper development of "concrete-colloid" within mass after each wetting.—*Linn H. Enslow.*

Pumping of Liquids in Chemical Plants. CLARK S. ROBINSON. Jour. Ind. Eng. Chem., **15**: 33, January, 1923. Description of various types of pumping apparatus found in use in water works and industrial plants. An elementary concrete description of most common classes of pumps and air-lift system. Characteristics and adaptability of each type are given. Cuts of pumps illustrate description and charts are used to explain characteristics, efficiency and cost finding in general for particular pumping problem. A table is given showing material of construction most resistant to a list of 133 different liquids. For those not thoroughly familiar with characteristics of various pumping equipment and pumping problems the article is of considerable value. It contains prime elements without detailed discussion, covering pumps and pumping in general, for water and liquids in general, of varying aggressivity, viscosity, gravity, and temperature.—*Linn H. Enslow.*

Contamination of Water Samples with Material Dissolved from Glass Containers. W. D. COLLINS AND H. B. RIFFENBERG. Jour. & Eng. Chem., **15**:

48, January, 1923. Samples of water in bottles of poor quality glass may, in a week or less, dissolve enough glass to add materially to alkalinity, silica and total solids contents. The less the original alkalinity of water the greater the solubility of the glass and consequent increase in dissolved solids, alkalinity and silica. A water originally containing no normal carbonate may show such present and one containing no hydroxide may show such present after contact with glass. Sodium and potassium content increases materially, whereas calcium, magnesium, iron, nitrates, chlorides and sulphates remain constant. Inferior bottles may be detected, therefore, by titration of alkalinity present in distilled water which has remained in them for period of two weeks or longer. —*Linn H. Enslow.*

Problems of Corrosion. B. D. SAKLATWALLA. Jour. Ind. &. Eng. Chem., **15**: 39, January, 1923. Experience and investigation have proved theory of corrosion based upon the electrolytic, the oxide and the colloidal theories, when applied experimentally produce results dependent upon phenomena of a more or less secondary origin. Influence from galvanic currents by two heterogeneous metals in presence of electrolytes, the reactions upon metals depending upon presence of oxygen, the protective influence of a coating of oxide on the metal, and dependence of corrosion on catalytic action of colloids formed during reaction, undoubtedly play great part in corrosion, but their influence can be masked by influences of more inherent nature. Such influence is surface tension of metal or alloy. Attention is directed to a study of this phenomenom as a channel for research on corrosion problems hitherto neglected. Regulation of surface tension by alloying or purifying or possibly heat treatment, etc. should be taken into serious consideration in future experimentation on problems of corrosion.—*Linn H. Enslow.*

Graphic Presentation of Water Analysis. W. D. COLLINS. Jour. Ind. & Eng. Chem., **15**: 394, April, 1923. Presentation of water analyses graphically in colors or with cross-lines and hatching. Includes the use of *milligram-equivalents*[1] of radicals that take part in equilibria of system rather than parts per million; as is being practiced by U. S. Geological Survey. Advantage lies in order of arrangement and use of certain color combinations. Analyses of four waters widely differing chemically, are shown in terms of parts per million as compared with milligram-equivalents. Alongside of figures is placed graphical picture of each water showing balanced analysis by means of placing each basic radical on one side of vertical line for comparison with each acid radical on opposite side. A correct analysis insures total of all acid radicals to equal total of all basic radicals when both are expressed as mgm. equivalents.—*Linn H. Enslow.*

Graphic Deductions Concerning the Degree of Dissociation of Weak Electrolytes. N. SCHOORL. Rev. trav. chim., **40**: 616-20, 1921. From Chem. Absts., **16**: 1037, April 10, 1922. Formulas developed for calculating degree of ioniza-

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[1] Mgm. equivalent $= \dfrac{\text{p.p.m.} \times \text{valence of radical}}{\text{atomic weight of the radical}}$.

tion of weak electrolytes. H-Ion concentration of weak acids obtained with good approximation by formula $[H^+] = a/V = \sqrt{K/V}$. Similar formula $[OH^-] = a/V$ holds for weak bases.—*R. E. Thompson.*

The Knowledge of the Radioactivity of Mineral Springs. ERICH EBLER AND A. J. VAN RHYN. Z. anorg. allgem. Chem., **119:** 135–44, 1921. From Chem. Abst., **16:** 1042, April 10, 1922. Examination showed thermal springs around Heidelberg to be high in radioactive substances.—*R. E. Thompson.*

Preservation of Starch Solution. N. KANO. J. Chem. Soc. (Japan) **42:** 974–5, 1921. From Chem. Abst., **16:** 1055, April 10, 1922. Most satisfactory preservative for starch solution for use in iodometric titration was found to be hydrochloric acid (0.5 cc. of twice normal hydrochloric acid to each 50 cc. of starch solution), when the titration was to be carried out in acid medium, and carbon bisulfide (one drop to each 50 cc.) when in neutral medium.—*R. E. Thompson.*

Artificial Stream Velocities in the Dirty Water Canal. F. BRUKNER. Deut. Zuckerind, **46:** 587, 1921. From Chem. Abst., **16:** 1025, March 20, 1922. A. device for obtaining sand-free water from dirty water canals is illustrated.—*R. E. Thompson.*

The Effect of Hard Water upon Tannin. H. C. REED. J. Am. Leather Chem. Assoc., **17:** 26–32, 1922. From Chem. Abst., **16:** 1031, March 20, 1922. Review and discussion of papers by Faust (C. A. 13, 3037) and by Wilson (C. A. 13, 1029). It is suggested that problem be attacked by operating dual system in experimental tannery, using distilled water in one system and hard water to be studied in other. (J. A. Wilson,—A paper now in preparation by Wilson and Kern has an important bearing on this subject. With increasing pH value up to 7.3 lime has a solvent action on so-called insolubles of quebracho extract, while at higher values it precipitates the tannins, precipitation being almost complete at pH 11.0.)—*R. E. Thompson.*

Kinetic and Static Coagulation Measurements with Suspensions. F. V. v. HAHN. Z. Elektrochem, **27:** 501–5, 1921; cf. C. A. **16:** 516. From Chem. Abst., **16:** 1037, April 10, 1922. Distinguishing characteristics of different diperse systems tabulated and discussed. Whether a solution belongs to molecular system or not may be determined by ascertaining whether it undergoes coagulation or flocculation. A kinetic method for coagulation measurements, based on weight of the sedimented suspensoid or determination of density of dispersion medium over sediment, is described. Results with his method agree with those obtained by static method.—*R. E. Thompson.*

New Investigational Methods for the Factory Waste Reaching River Courses and Purification Processes to be Recommended in Order that Undesirable Matter Shall Escape when Waste Waters are Carefully Controlled. DORFMÜLLER. Deut. Zuckerind, **46:** 570–3, 1921. From Chem. Abst., **16:** 1021, March 20, 1922. In pond fermentation process as used at Dinklar, Bockenem, and Schel-

lerten, waste waters flow to small, deep ponds where fermentation causes foam blanket to cover surface. When lactic acid stops fermentation, water is passed to other ponds where 80 per cent of the acid is neutralized with milk of lime and fermentation continued. By passing through 3 ponds impurities can be almost completely eliminated. The "biological self-purification" process of Kolkwitz is described briefly.—*R. E. Thompson.*

What Are the Most Important Methods of Examination of Factory Waste Waters Discharging into Streams, and What Purification Processes for Waste Waters Should be Recommended According to the Latest Knowledge, in order that Nothing Undesirable Shall Appear in the Waste Waters Carefully Controlled as Governmentally Required? H. STENTZEL. Deut. Zuckerind, **46:** 586–7, 1921. From Chem. Abst., **16;** 1025, March 20, 1922. Press and diffusion waters passed through 2 pulp catchers. About 60 per cent of mixed, depulped waters is returned to battery. Remainder of water is heated to 50° by waste heat and subjected to aërobic lactic acid fermentation. It is necessary to aërate water to prevent butyric acid fermentation. After fermentation water is cooled quickly to hold as much carbon dioxide in solution as possible, in order to aid precipitation of suspended matter.—*R. E. Thompson.*

The Concentration of Hydrogen Ions in the Soil. G. OLSEN. Science **54:** 539–41, 1921. From Chem. Abst., **16:** 981, March 20, 1922. Fixed and constant relationship between kinds of vegetation and H-ion concentration of soil. Habitats with about same H-ion concentration and similar as regards light and moisture carry about same vegetation. Many species are only found in soil where H-ion concentration is within a certain range characteristic for each single species. Number of species found and density of species were greatest in soil near neutral point and became less as H-ion concentration of soil increased.—*R. E. Thompson.*

The Protection of Concrete and Cement against the Action of Sulfates by Means of Barium Carbonate. H. NITZSCHE. Zement, **10:** 1–2, 13–5, 1921. Chimie et industrie, **6:** 799, 1921. From Chem. Abst., **16:** 998, March 20, 1922. Action of further quantities of sulfates in cement takes place quite readily after all added barium carbonate has been converted to sulfate. The reaction $BaCO_3 + CaSO_4 = BaSO + CaCO_3$ is probably not the only one, and other reactions and accessory physical changes probably come into play. Mortars to which no barium carbonate had been added behaved very well, both when immersed in sulfate-bearing waters and when exposed to atmosphere for 4 weeks, while all samples treated with barium carbonate behaved abnormally to varying degrees.—*R. E. Thompson.*

The Radioactivity of the Water of Mt. Dore. P. LOISEL AND R. CASTELNAU. Compt. rend., **173:** 1390–2, 1921. From Chem. Abst., **16:** 1042, April 10, 1922. Variation of emanation of Mt. Dore waters with source and time.—*R. E. Thompson.*

Denitrification by Bacteria and its Relation to Water Analysis. K. SCHERINGA Rept. Central Lab. Pub. Health Service (Netherlands), 1920, 165–71; Pub.

Health Eng. Absts. March 11, 1922. From Chem. Absts., 16: 1289, April 20, 1922. Owing to instability of various forms of combined nitrogen in solution, analysis of water should proceed at earliest opportunity—*R. E. Thompson.*

A Method of Direct Aeration of Stored Water. W. Scott and A. L. Foley. Proc. Indiana Acad. Sci., 1919, 71–4. From Chem. Abst., 16: 1289, April 20, 1922. Aeration apparatus, used at the pumping station of Indiana University, takes advantage of fact that it takes less energy to carry air into water than it does to force water into air. Use of apparatus improved quality of water but part of purification was due to convection currents caused by rising bubbles.—*R. E. Thompson.*

Paints for Light Oil Storage Tanks, and a Note on a Spray Equipment. H. A. Gardner. Paint Mfrs. Assoc. of U. S., Circ. 131, 8pp., August, 1921. From Chem. Abst., 16: 1385, April 20, 1922. Large storage tanks may be conveniently painted by use of spray gun let down over sides of tank by rope and windlass. Various portable spray painting equipments and uses are illustrated.—*R. E. Thompson.*

Influence of Degree of Acidity on the Tannin Content of Solutions. F. C. Thompson, K. Seshachalam and K. H. Hassan. J. Soc. Leather Trades Chem. 5: 389–92, 1921. From Chem. Abst., 16: 1335, April 20, 1922. Time of filtration, color, content of tannins, and insolubles are all likely to vary considerably with change in H-ion concentration—*R. E. Thompson.*

Electroadsorption as a Purely Chemical Phenomenon. Wo Ostwald. Kolloid Z., 30: 254–60, 1922. From Chem. Abst., 16: 2053, July 10, 1922 Law of mass action can yield practical results only when in place of stoichiometric mass of absorbent there is substituted active mass, which consists of sum of chemically active surface layers.—*R. E. Thompson.*

Chemical Reactions and Radii of Curvature. R. Luce. Compt. rend., 172: 1287–8, 1921; cf. Reboul and Luce, C. A. 15, 2375. From Chem. Abst., 16: 2058, July 10, 1922. Further experiments are quoted in support of view that chemical action of liquid on solid depends on shape of latter, being greatest at those points where mean curvature is greatest.—*R. E. Thompson.*

The Theory of the Migration Velocity of Particles in a Viscous Medium when Acted on by an External Force. H. F. Mayer. Jahrb. Radioakt. Elektronic, 18: 201–39, 1921. From Chem. Abst., 16: 2053, July 10, 1922.—*R. E. Thompson.*

Adhesive Forces in Solution. II. Studies on Adhesion Series. N. Schilow. Z. physik. Chem., 100: 45–62, 1922. From Chem. Abst., 16: 2055, July 10, 1922. Discussion of absorption. Important, but not suitable for abstraction. *R. E. Thompson.*

Simple Hydrogen Generator for Use in Making H-ion Concentration Measurements. P. H. Cathcart. J. Ind. Eng. Chem., 14: 278, 1922. From Chem. Abst. 16: 1339, May 10, 1922.—*R. E. Thompson.*

Flue Gas Testers. F. O. BINDER. Chem. Ztg., **46**: 149-51, 1922. From Chem. Abst., **16**: 1340, May 10, 1922. Schumacher's "Oekonometer," Maihack's "Duplex-Mono" and the "Union gas tester" are described and illustrated.—*R. E. Thompson.*

Transmission Colors of Sulfur Suspensions. C. V. RAMAN AND B. RAY. Calcutta Univ. Proc. Roy. Soc., (London), 100A, 102–9, 1921; cf. Chem. Abst., **8**: 1056; **9**: 884. From Chem. Abst., **16**: 1341, May 10, 1922. Light transmitted through sulfur suspensions is graphically shown to be function of radius of particles forming suspension. There is an augmentation of transparency when circumference of particles is about 6λ.—*R. E. Thompson.*

Quickly Acting Hydrogen Electrode. P. J. MOLONEY. J. Phys. Chem., **25**: 758–61, 1921. From Chem. Abst., **16**: 1341, May 10, 1922. A new form of electrode, in which platinum dips into small drop of solution held in glass loop in atmosphere of hydrogen.—*R. E. Thompson.*

Clay as an Ampholyte. O. ARRHENIUS. J. Am. Chem. Soc., **44**: 521–4, 1922. From Chem. Abst., **16**: 1350, May 10, 1922. Clay, irrespective of its source, acts as an amphoteric electrolyte. Theoretical and practical importance of this is discussed.—*R. E. Thompson.*

"Disglomeration" and the Autogenous Formation of Lead Trees. A. THIEL. Ber., 54B, 2755–8, 1921. From Chem. Abst., **16**: 1345, May 10, 1922. Experiments on action of reagents on reguline metals and crystallites are described which may be of interest in connection with corrosion. Lead tree formation was always preceded by formation of white coating of basic salt upon metal.—*R. E. Thompson.*

The Salt Error with Coloring Indicators. I. M. KOLTHOFF. Rec. trav. chim. **41**: 54–67, 1922. From Chem. Abst., **16**: 1346, May 10, 1922. Determination of pH with indicators is simpler and more rapid than by electrometric method. Salts and albuminoid substances, however, give rise to errors (Sörensen. Biochem. Z., 21; 131; C. A. 4, 607). Methods employed to determine these errors are described.—*R. E. Thompson.*

An Elaboration of the Indicator Method Without Buffers. L. MICHAELIS AND R. KRÜGER. Biochem. Z., **119**: 307–27, 1921; cf. C. A., **15**: 1427. From Chem. Abst., **16**: 1346, May 10, 1922. Determination of temperature coefficient and salt error of m-nitrophenol is reported and new indicator, dinitrophenol, is described. Question of change in pH by addition of indicator is dealt with and possibility that part of salt effect consists in alteration of the chromogenic properties of chromatophore group of dyestuff by neutral salts is discussed.—*R. E. Thompson.*

Making Individual Submicrons in the Tyndall Cone Evident to the Naked Eye. I. TRAUBE AND P. KLEIN. Kolloid Z., **30**: 19–20, 1922. From Chem. Abst.,

16: 1349, May 10, 1922. Method and apparatus described by means of which observations on particles of lead carbonate, of submicron size, were made with naked eye.—*R. E. Thompson.*

Methods of Investigation at the Institute for Colloidal Research in Frankfurt a M. 111. Investigation of Preparations of Colloidal Silicic Acid. ANON. Chem. Ztg., 45: 1249-50, 1921; cf. C. A., 14: 2574. From Chem. Abst., 16: 1349, May 10, 1922. Ultrafiltration was found to be superior to the ultramicroscope and Kleinmann's nephelometer in the determination of the size of particles in silicic acid sols.—*R. E. Thompson.*

The Law of Distribution in Colloid Solutions. E. F. BURTON AND MISS E. BISHOP. Proc. Roy. Soc., (London), 100A, 414-9, 1922. From Chem. Abst., 16: 1350, May 10, 1922. A colloidal solution of copper which had been allowed to stand undisturbed for 50 days at almost constant temperature was found to be uniform in composition throughout the body of liquid, indicating that the variation in concentration at different depths expressed in Perrin's distribution law must be confined to a very small distance from the surface.—*R. E. Thompson.*

Adsorption of Precipitates. V. Adsorption during the Precipitation of Colloids by Mixtures of Electrolytes. H. B. WEISER. J. phys. Chem., 25: 665-83, 1922; cf. C. A. 16: 5. From Chem. Abst., 16: 1351, May 10, 1922. Experiments showed that functions which influence precipitating action of mixtures of electrolytes are effect of presence of each precipitating ion on adsorption of other ion and stabilizing action of ions having same charge as colloid.—*R. E. Thompson.*

Proposed Filtration Plant for Windsor, Ontario. E. M. PROCTOR. Canadian Engineer, 43; 23, 605, December 25, 1923. Supply will be drawn from Detroit River, delivered by 36-inch main to mixing basin. Water will then pass into coagulation basin having 2 hour settling period, after which it will be discharged onto rapid sand filters. Estimated cost of construction $509,000. Annual cost of operation $102,000.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Industrial Effluent Disposal. Canadian Engineer, 43: 13, 395, September 26, 1922. Prevention of tastes and odors resulting from chlorination of waters containing phenol or its derivatives.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Note on Stablized Bleaching Powder for Tropical Use. F. S. AUMONIER AND S. ELLIOTT. Jour. Royal Army Medical Corps. 39: 6, 459, December, 1922. Bleach stabilized with 20 per cent quicklime will stand ordinary storage in tropical climates in four-ounce sealed tins and after opening will not deteriorate to any appreciable extent in a few days.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Strange St. Pumping Station, Kitchener, Ontario. M. PEQUEGNAT. Canadian Engineer, 44: 4, 159. January 23, 1923. Nine new artesian wells supply-

ing approximately 2 million gallons per day have been drilled. Sulphur in deeper wells is eliminated by air of air lift system.—*A. W. Blohm.* (*Courtesy I. W. M.*)

The Water Supply Problem of Philadelphia. Bureau of Municipal Research of Philadelphia, May, 1922. Inadequate pressures and volumes in certain districts; breakdowns in plant and equipment, and objectionable tastes and odors recurring periodically. Objectionable tastes and odors from Schulykill supplies, due to decaying organic matter, and industrial wastes. Study of future sources. Large quantities of sewage necessitate study of loading capacities of purification plants.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Mechanical Equipment of Water Works System. G. R. COLLINSON. Canadian Engineer, **44**: 4, 169, January 23, 1922. Discussion includes meteorological and flow gauging apparatus, pumping machinery, draw-off arrangements for reservoirs, sluices, valves, pipes, meters, rapid filters, chemical feed, sterilizing and softening apparatus, waste detection devices and machines for drilling and tapping mains.—*A. W. Blohm.* (*Courtesy I. W. M.*)

Simple Goiter as a Result of Iodine Deficiency. J. F. MCCLENDON AND AGNES WILLIAMS. Jour. Am. Med. Assoc., **80**: 9, 600, March 3, 1923. Effect of water on goiter. Comparison of iodine content in drinking water and distribution of goiter throughout United States. Division of country into four zones shows, 0.01 to 0.1 parts per billion iodine with 15–30 case rate per 1000 in first zone; 0.015 to 1.2 p.p.b. iodine, 5–15 rate per 1000, in second; 0.06 to 9 p.p.b., 1–5 rate per 1000 in third; and 1.4–10 p.p.b., 0–1 rate per 1000 in fourth zone.—*A. W. Blohm.*